BLOOMFIELD BOARD OF EDUCATION
Administration Offices
155 Broad Street
Bloomfield, NJ 07003

Advanced Placement Chemistry
Curriculum Guide
Grade 12
2017

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Conforms to the Next Generation Science Standards and NJSLS Standards

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Content Area Standards

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Technological Literacy

8.1 Educational Technology

All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.

Technology Strand (Delete what is not applicable to this Guide.)
• Strand
HS

A. Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems and operations.
• Understand and use technology systems. • Select and use applications effectively and productively.

HS 8.1.12.A.1 Create a personal digital portfolio which reflects personal and academic interests, achievements, and career aspirations by using a variety of digital tools and resources. 8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review. 8.1.12.A.3 Collaborate in online courses, learning communities, social networks or virtual worlds to discuss a resolution to a problem or issue. 8.1.12.A.4 Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results. 8.1.12.A.5 Create a report from a relational database consisting of at least two tables and describe the process, and explain the report results.

B. Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using technology.
• Apply existing knowledge to generate new ideas, products, or processes. • Create original works as a means of personal or group expression.
HS 8.1.12.B.2 Apply previous content knowledge by creating and piloting a digital learning game or tutorial.

C. Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.
• Interact, collaborate, and publish with peers, experts, or others by employing a variety of digital environments and media.

- Communicate information and ideas to multiple audiences using a variety of media and formats.
- Develop cultural understanding and global awareness by engaging with learners of other cultures.
- Contribute to project teams to produce original works or solve problems.

HS
8.1.12.C.1
Develop an innovative solution to a real world problem or issue in collaboration with peers and experts, and present ideas for feedback through social media or in an online community.

D. Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior.

- Advocate and practice safe, legal, and responsible use of information and technology.
- Demonstrate personal responsibility for lifelong learning.
- Exhibit leadership for digital citizenship.

HS
8.1.12.D.1
Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.

8.1.12.D.2
Evaluate consequences of unauthorized electronic access (e.g., hacking) and disclosure, and on dissemination of personal information.

8.1.12.D.3
Compare and contrast policies on filtering and censorship both locally and globally.

8.1.12.D.4
Research and understand the positive and negative impact of one's digital footprint.

8.1.12.D.5
Analyze the capabilities and limitations of current and emerging technology resources and assess their potential to address personal, social, lifelong learning, and career needs.

E: Research and Information Fluency: Students apply digital tools to gather, evaluate, and use information.

• Plan strategies to guide inquiry • Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media. • Evaluate and select information sources and digital tools based on the appropriateness for specific tasks.
HS 8.1.12.E.1 Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources. 8.1.12.E.2 Research and evaluate the impact on society of the unethical use of digital tools and present your research to peers.

F: Critical thinking, problem solving, and decision making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.
• Identify and define authentic problems and significant questions for investigation. • Plan and manage activities to develop a solution or complete a project. • Collect and analyze data to identify solutions and/or make informed decisions. • Use multiple processes and diverse perspectives to explore alternative solutions
HS 8.1.12.F.1 Evaluate the strengths and limitations of emerging technologies and their impact on educational, career, personal and or social needs.

8.2 Technology Education, Engineering, Design, and Computational Thinking-Programming

All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.

A. The Nature of Technology: Creativity and Innovation Technology systems impact every aspect of the world in which we live.

• The characteristics and scope of technology. • The core concepts of technology. • The relationships among technologies and the connections between • technology and other fields of study.
HS 8.2.12.A.1 Propose an innovation to meet future demands supported by an analysis of the potential full costs, benefits, trade-offs and risks, related to the use of the innovation. 8.2.12.A.2 Analyze a current technology and the resources used, to identify the trade-offs in terms of availability, cost, desirability and waste. 8.2.12.A.3 Research and present information on an existing technological product that has been repurposed for a different function.

B. Technology and Society: Knowledge and understanding of human, cultural and societal values are fundamental when designing technological systems and products in the global society.
• The cultural, social, economic and political effects of technology. • The effects of technology on the environment. • The role of society in the development and use of technology. • The influence of technology on history.
HS 8.2.12.B.1 Research and analyze the impact of the design constraints (specifications and limits) for a product or technology driven by a cultural, social, economic or political need and publish for review. 8.2.12.B.2 Evaluate ethical considerations regarding the sustainability of environmental resources that are used for the design, creation and maintenance of a chosen product. 8.2.12.B.3 Analyze ethical and unethical practices around intellectual property rights as influenced by human wants and/or needs. 8.2.12.B.4 Investigate a technology used in a given period of history, e.g., stone age, industrial revolution or information age, and identify their impact and how they may have changed to meet human needs and wants. 8.2.12.B.5 Research the historical tensions between environmental and economic considerations as driven by human needs and wants in the development of a technological product, and present the competing viewpoints to peers for review.

C. Design: The design process is a systematic approach to solving problems.
• The attributes of design. • The application of engineering design. • The role of troubleshooting, research and development, invention and innovation and experimentation in problem solving.
HS 8.2.12.C.1 Explain how open source technologies follow the design process. 8.2.12.C.2 Analyze a product and how it has changed or might change over time to meet human needs and wants. 8.2.12.C.3 Analyze a product or system for factors such as safety, reliability, economic considerations, quality control, environmental concerns, manufacturability, maintenance and repair, and human factors engineering (ergonomics). 8.2.12.C.4 Explain and identify interdependent systems and their functions. 8.2.12.C.5 Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled. 8.2.12.C.6 Research an existing product, reverse engineer and redesign it to improve form and function. 8.2.12.C.7 Use a design process to devise a technological product or system that addresses a global problem, provide research, identify trade-offs and constraints, and document the process through drawings that include data and materials.

D. Abilities for a Technological World: The designed world is the product of a design process that provides the means to convert resources into products and systems.

- Apply the design process.
- Use and maintain technological products and systems.
- Assess the impact of products and systems.

HS
8.2.12.D.1 Design and create a prototype to solve a real world problem using a design process,
identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.

8.2.12.D.2 Write a feasibility study of a product to include: economic, market, technical, financial, and management factors, and provide recommendations for implementation.

8.2.12.D.3 Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system.

8.2.12.D.4 Assess the impacts of emerging technologies on developing countries.

8.2.12.D.5 Explain how material processing impacts the quality of engineered and fabricated products.

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8.2.12.D.6 Synthesize data, analyze trends and draw conclusions regarding the effect of a technology on the individual, society, or the environment and publish conclusions.

E. Computational Thinking: Programming: Computational thinking builds and enhances problem solving, allowing students to move beyond using knowledge to creating knowledge.

- Computational thinking and computer programming as tools used in design and engineering.

HS
8.2.12.E.1 Demonstrate an understanding of the problem-solving capacity of computers in our world.

8.2.12.E.2 Analyze the relationships between internal and external computer components.

8.2.12.E.3 Use a programming language to solve problems or accomplish a task (e.g., robotic functions, website designs, applications, and games).

8.2.12.E.4 Use appropriate terms in conversation (e.g., troubleshooting, peripherals, diagnostic software, GUI, abstraction, variables, data types and conditional statements).

21st Century Life and Careers

Career Ready Practices

CRP1. Act as a responsible and contributing citizen and employee.
CRP2. Apply appropriate academic and technical skills.
CRP3. Attend to personal health and financial well-being.
CRP4. Communicate clearly and effectively and with reason.
CRP5. Consider the environmental, social and economic impacts of decisions.
CRP6. Demonstrate creativity and innovation.
CRP7. Employ valid and reliable research strategies.
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them.
CRP9. Model integrity, ethical leadership and effective management.
CRP10. Plan education and career paths aligned to personal goals.
CRP11. Use technology to enhance productivity.
CRP12. Work productively in teams while using cultural global competence.

Course Description

Overview

· AP Chemistry meets twice a week for 96 – minute period and three times per week for 48 – minute period.
· Labs are conducted during the 96 – minute periods twice a week and completed after school if there is extra time is needed.
· Approximately 20 labs are conducted each year. In addition demonstration labs are conducted.
· The school year is divided into 4 marking periods, quarterly exams are held.
· Recitations are held after school for one to two hours on Thursdays. Course Design
· The course is designed to help students to be able to analyze scientific and societal issues using the scientific problem solving model.
· They will be prepared to be critical and independent thinkers who are able to function effectively in a technological and scientific society.

· Students will individually physically perform each experiment by following instructions on using equipment and materials to make relevant observations and collect data.
· They will use the collected data to calculate, form conclusions, and verify hypotheses.
· They will compare results with each other and communicate formally in written reports on all labs.
· Students will also be able to make acceptable scores on the AP Chemistry Examination in May through hard work.
· At the end of each topic all students are required to access “scienceintheclassroom.org” read a paper of their choosing and write a 3 paragraph paper explaining the article and what they learned from it.

Laboratory Work:
All of the laboratory experiments in this course are hands-on. Students work individually or in a group of two depending upon the lab. They collect, process, manipulate, and graph data from both qualitative and quantitative observations. Inquiry is emphasized in many of the experiments that students complete. The laboratory work requires students to design, carry out, and analyze data using guided inquiry principles. For all labs, students are required to report in the following format and submit for grading
[CR 7].
Title
Purpose
Materials
Safety
Procedure – written in the past tense (describing the work done)
Observation – includes data tables, graphs, calculations, analysis, answers to questions posed in the lab.
Conclusion – (prompts) –
- Restate purpose
- Did you achieve your purpose?
- How do you know that you have achieved your purpose (explain in detail)
- Problems/Errors that occurred in the lab
- Improvements to the lab.

All laboratory experiments are intended to be completed in one double period (95 minutes) except the following guided-inquiry labs that require two days of work or two double lab periods:
1. Determination of the Formula of a Compound
2. Finding the Ratio of Moles of Reactants in a Chemical Reaction
3. Identification of an Unknown Ionic Salt
4. Hess’s Law
5. Relationship between the Spectrum and Absorbance of Light

6. Conductivity of Solids & Metals
7. Factors that affect reaction rates and determining reaction rates and reaction mechanisms
8. Equilibrium Position
9. Hydrolysis of Salts
10. Electrochemical Cells

Technology:
Students use probes in laboratory work to gather data.

Laboratory Notebook:
A laboratory portfolio is required for the course. All completed lab reports documenting all lab experiences must be included in the portfolio. The portfolio is checked every three weeks with a final check at the end of the course.

Assignments:
Chapter readings, Problem sets and Current topics are assigned on a weekly basis.

Tests:
A unit test is assigned for each unit. A final exam at the end of the year.

AP Exam Review:
The final ten full class days before the AP Chemistry Exam are used for exam review and practice tests using old AP Chemistry exam materials. Students work in cooperative groups to solve a packet of free response problems from previous exams. Students practice net ionic equations and are quizzed on their progress. Several practice
AP Exams are administered as part of the two-week review prior to the AP Chemistry Exam.

Adopted Text(s)

Text

Chemistry, 10th Edition, Zumdahl Zumdahl DeCoste, Cengage Learning, AP Edition ,ISBN -
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8. All labs are from this text unless otherwise stated.

Additional Help - Chemistry Principles and Reactions by William L. Masterton and Cecile N. Hurley, Updated 7th ed, Thomson Brooks/Cole, 2012, ISBN 13:978-1-111-42710-8 and ISBN 10:1-111-42710-0.

Adopted Resources

Include resources to be used in addition to adopted textbook(s).

Additional Resources

Include as appropriate: SmartBoard Notebook or Interactive LCD files, Web 2.0 Resources, Discovery Streaming video, Defined STEM lesson, Newsela topics or articles, NY Times Educational Resource, etc.

AP Chemistry Big Ideas

Big Idea 1: The chemical elements are fundamental building materials of matter, and all matter can be understood in terms of arrangements of atoms. These atoms retain their identity in chemical reactions.

Big Idea 2: Chemical and physical properties of materials can be explained by the structure and the arrangement of atoms, ions, or molecules and the forces between them.

Big Idea 3: Changes in matter involve the rearrangement and/or reorganization of atoms and/or the transfer of electrons.

Big Idea 4: Rates of chemical reactions are determined by details of the molecular collisions.

Big Idea 5: The laws of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter.

Big Idea 6: Any bond or intermolecular attraction that can be formed can be broken. These two processes are in a dynamic competition, sensitive to initial conditions and external perturbations.

Science Practices for AP Chemistry

A practice is a way to coordinate knowledge and skills in order to accomplish a goal or task. The science practices enable students to establish lines of evidence and use them to develop and refine testable explanations and predictions of natural phenomena. These science practices capture important aspects of the work that scientists engage in, at the level of competence expected of AP Chemistry students.

Science Practice 1: The student can use representations and models to communicate scientific phenomena and solve scientific problems.

1.1 The student can *create representations and models* of natural or man-made phenomena and systems in the domain.

1.2 The student can *describe representations and models* of natural or manmade phenomena and systems in the domain.

1.3 The student can *refine representations and models* of natural or man-made phenomena and systems in the domain.

1.4 The student can *use representations and models* to analyze situations or solve problems qualitatively and quantitatively.

1.5 The student can *re-express key elements* of natural phenomena across multiple representations in the domain.

Science Practice 2: The student can use mathematics appropriately.

2.1 The student can *justify the selection of a mathematical routine* to solve problems.

2.2 The student can *apply mathematical routines* to quantities that describe natural phenomena.

2.3 The student can *estimate numerically* quantities that describe natural phenomena.

Science Practice 3: The student can engage in scientific questioning to extend thinking or to guide investigations within the context of the AP course.

3.1 The student can *pose scientific questions*.

3.2 The student can *refine scientific questions*.

3.3 The student can *evaluate scientific questions.*

Science Practice 4: The student can plan and implement data collection strategies in relation to a particular scientific question.

4.1 The student can *justify the selection of the kind of data* needed to answer a particular scientific question.

4.2 The student can *design a plan* for collecting data to answer a particular scientific question.

4.3 The student can *collect data* to answer a particular scientific question.

4.4 The student can *evaluate sources of data* to answer a particular scientific question.

Science Practice 5: The student can perform data analysis and evaluation of evidence.

5.1 The student can *analyze data* to identify patterns or relationships.

5.2 The student can *refine observations and measurements* based on data analysis.

5.3 The student can *evaluate the evidence provided by data sets* in relation to a particular scientific question.

Science Practice 6: The student can work with scientific explanations and theories.

6.1 The student can *justify claims with evidence*.

6.2 The student can *construct explanations of phenomena based on evidence* produced through scientific practices.

6.3 The student can *articulate the reasons that scientific explanations and theories are refined or replaced*.

6.4 The student can *make claims and predictions about natural phenomena* based on scientific theories and models.

6.5 The student can *evaluate alternative scientific explanations*.

Science Practice 7: The student is able to connect and relate knowledge across various scales, concepts, and representations in and across domains.

7.1 The student can *connect phenomena and models* across spatial and temporal scales.

7.2 The student can *connect concepts* in and across domain(s) to generalize or extrapolate in and/or across enduring understandings and/or big ideas.

Unit 1

Unit #1:	Chemical Foundations (Review)
Suggested Timeframe:	8 days
Subject/Topic:	Lab Safety, Matter, and Measurement (Review)
DESIRED RESULTS	
Established Goals:	Science Practices: 5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. 5.1.12.B.2: Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. 5.1.12.D.1: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. 5.1.12.D.2: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. 5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. Physical Science: 5.2.12.A.2: Account for the differences in the physical properties of solids, liquids, and gases. 5.2.12.A.3: Predict the placement of unknown elements on the Periodic Table based on their physical and chemical properties. 5.2.12.A.4: Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes. 5.2.12.B.1: Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form. Technology: 8.1.12.A.1: Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results.

	21st Century Life & Career: 9.1.12.A.1: Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.B.1: Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. 9.1.12.C.4: Demonstrate leadership and collaborative skills when participating in online learning communities and structured learning experiences. 9.1.12.C.5: Assume a leadership position by guiding the thinking of peers in a direction that leads to successful completion of a challenging task or project.
Enduring Understandings:	The most important aspect of chemistry is not the memorization of the laws and definitions, but rather the ability to explain how the laws and relationships arise because of the atomic nature of matter. All matter is made of atoms and there are a limited number of types of atoms; these are the elements. There are limited number of types of atoms, these are the elements The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds.
Essential Questions:	What are the implications of students not following safety rules in an AP Chemistry course or other college-level general chemistry courses? What macroscopic clues can be used to determine whether a physical or chemical change has occurred? Why is it important to be able to separate mixtures, and how do chemists achieve such separation?
Critical Vocabulary	Scientific Method, Measurement, Hypothesis, Theory, model, aural law, Law of Conservation of Mass, SI system, Mass Weight, Uncertainty, Significant Figures, Accuracy, Precision, Random Error, systematic error, Dimensional Analysis, Density, Matter, Heterogeneous mixture, Homogeneous mixture, Solution, Pure substance, Physical change, Distillation, Filtration, Chromatography, Paper Chromatography, Compound, Chemical change, Chemical. Law of Definite Proportion, Law of Multiple Proportion, Atomic Mass, Atomic Weight, Avogadro’s Hypothesis, cathode ray tube, Radioactivity, Electron, Nuclear atom, Nucleus, Proton, Neutron, Isotope, Atomic number, Mass number, Chemical bond, Molecular bond, Molecule, Chemical formula, Structural formula, Ion, Cation, Anion, Ionic bond, Ionic solid, Polyatomic ion,
All Students Will Know and Be Able To. . .	translate among macroscopic observations of change, chemical equations, and particle views. [LO 3.1, SP 1.5, SP 7.1] provide support for the claim about whether a process is a chemical or physical change (or may be classified as both)

	based on whether the process involves changes in intramolecular versus intermolecular interactions. [LO 5.10, SP 5.1] explain how solutes can be separated by chromatography based on intermolecular interactions. [LO 2.7, SP 6.2] design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components. [LO 2.10, SP 4.2, SP 5.1, SP 6.4 translate among macroscopic observations of change, chemical equations, and particle views. [LO 3.1, SP 1.5, SP 7.1] support the claim about whether a process is a chemical or physical change (or may be classified as both) based on whether the process involves changes in intramolecular versus intermolecular interactions. [LO 5.10, SP 5.1] design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components. [LO 2.10, SP 4.2, SP 5.1, SP 6.4]
EVIDENCE OF STUDENT LEARNING	
Formative Performance Task:	Lab Safety Rules Practice Quiz on Flinn. Ladies and Gentlemen you will demonstrate your knowledge of safety rules and proper use of lab safety equipment. There are 20 safety errors in the film. Ladies and Gentlemen you will practice using physical data and appropriate units of measurement to calculate density on the following assessments: • Matter, Elements, and Compounds: You will identify different states of matter and compare and contrast elements and compounds. • Scientific Notation: You will translate or convert between numbers in scientific notation and regular decimals. • Significant Figures: You will calculate numbers and apply significant figure rules to their answers. • Conversions: You will use dimensional analysis to convert between different units of chemical quantities. • Density: You will calculate density, mass, or volume from lab data and relate it to the different particular models for the different phases of matter.

	Ladies and Gentlemen you will practice translating among macroscopic observations and particulate representations with the following assessments: • Physical and Chemical Changes: You will identify a picture as demonstrating a physical or chemical change. • Heterogeneous and Homogeneous Mixtures: Looking at pictures, you will determine whether a mixture is homogeneous or heterogeneous. • Mixture Separation: You will identify the best technique to separate a mixture in different scenarios I introduce various simulated mass spectra, and students use them to answer such questions as, Which element might this be? Does this sample contain 1. An impurity? Can you rule out the presence of argon in this sample?
Summative Performance Task:	Lab Safety Rules Final Quiz: Students demonstrate knowledge of safety rules and proper use of lab safety equipment. In a 45-minute quiz, students answer. The multiple-choice questions focus on the concepts learned, 1.1 to 1.7 Standards, along with mixture separation. The free-response question requires students to choose methods to separate different mixtures, justify their choices, and develop lab procedures to accomplish the separation. Students are given certain units and asked to convert to other units. Students are given a graph and asked to read certain data points ,
Formal Evidence of Learning & Progress:	Written Responses Quiz Test Examinations of Student Work
Informal Evidence of Learning & Progress:	Exit Cards Reading Assessments (Oral, etc.) Pre-Assessments Checklists Peer Review Informal Observations/Dialogues Think A-louds Self-Assessment /Reflection

LEARNING PLAN	
Required Activities:	Hook – A demo of acid in the eyes using vinegar and eggs. Pre-assess – Q & A Focus Activity – A tour of the lab and equipment and their uses Lab experiments - Density, - Separating mixtures, - And others Problem sets - Textbook Chap 1 & 2 - Handouts Online quizzes Students will tour lab, identifying lab safety equipment and defining their application to safety. The demonstrations give students a visual of the potential dangers of getting acids in their eyes and wearing contacts in the lab. The fire extinguisher demo shows students the proper way to use a fire extinguisher.
Required Resources:	Handout – Flinn Safety Sheet and Apparatus worksheets. Read Text – Chemistry Zumdahl Zumdahl DeCoste 10th Edition Cengage Learning online.
Suggested Activities:	Lab experiments – 1 period experiments Problem sets Kahn Academy
Suggested Resources:	Read handouts. Read text Online quizzes
Strategies for Differentiation:	Differentiating content: Readiness- small-group instruction, homework, compacting, multiple-entry points Interest - choices of books, homework options, explorations by interest and modes of expression (artistic, technological,

	written, oral) Learning Style: organizational options, working choice options, flexible environment, Multiple Intelligences options

Unit 2

Unit #2:	Review of Nomenclature and Stoichiometry
Suggested Timeframe:	10 days
Subject/Topic:	Nomenclature Stoichiometry Solution Stoichiometry
DESIRED RESULTS	
Established Goals:	Science Practices: 5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. 5.1.12.B.1: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. 5.1.12.B.4: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. 5.1.12.D.2: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. 5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. Physical Science: 5.2.12.A.1: Use atomic models to predict the behaviors of atoms in interactions. 5.2.12.B.1: Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form. 5.2.12.B.3: Balance chemical equations by applying the law of conservation of mass Technology: 8.1.12.A.1: Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate

	charts and graphs, and interpret the results. 21st Century Life & Career: 9.1.12.A.1: Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.B.1: Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. 9.1.12.C.4: Demonstrate leadership and collaborative skills when participating in online learning communities and structured learning experiences. 9.1.12.C.5: Assume a leadership position by guiding the thinking of peers in a direction that leads to successful completion of a challenging task or project.
Enduring Understandings:	Chemical changes are represented by a balanced chemical equation that identifies the ratios with which reactants react and products form. [EU 3.A] Chemical reactions can be classified by considering what the reactants are, what the products are, or how they change from one into the other. Classes of chemical reactions include synthesis, decomposition, acid-base, and oxidation-reduction reactions. [EU 3.B] Chemical and physical transformations may be observed in several ways and typically involve a change in energy. [EU 3.C]
Essential Questions:	Brass was used in ancient times for currency and in art. The composition of the alloy can help archaeologists determine the age and its creator. How is the composition determined? How do chemical engineers ensure that expensive reactants are completely used in a manufacturing process?
Critical Vocabulary	Chemical Stoichiometry, Mass Spectrometer, Average Atomic Mass, Mole, Avogadro's Number, Molar mass, Empirical Formula, Molecular Formula, Chemical Equation, reactant, Product, Balanced Chemical Equation, mole ratio, stoichiometric mixture, Limiting reactant, Excess reactant, Percent yield, Aqueous solution, Hydration, Solubility, Solute, Solvent, Electrical Conductivity, Strong electrolyte, Weak electrolyte, nonelectrolyte, Strong acid, Weak acid, Strong base, Weak base, Molarity, Standard solution, Dilution, Precipitation Reaction, Precipitate, Spectator ion, Net ionic equation, neutralization reaction titration, stoichiometric (equivalence) point, Indicator, Endpoint. Oxidation – Reduction (Redox) reaction, Oxidation, Reduction, Oxidation state, Oxidizing agent, Reducing agent, Half reaction

All Students Will Know and Be Able To. . .	Molecules are composed of specific combinations of atoms; different molecules are composed of combinations of different elements and of combinations of the same elements in differing amounts and proportions. [EK 1.A.1] Conservation of atoms makes it possible to compute the masses of substances involved in physical and chemical processes. Chemical processes result in the formation of new substances, and the amount of these depends on the number and the types and masses of elements in the reactants, as well as the efficiency of the transformation. [EK 1.E.2] A chemical change may be represented by a molecular, ionic, or net ionic equation. [EK 3.A.1] Quantitative information can be derived from stoichiometric calculations that utilize the mole ratios from the balanced chemical equations. The role of stoichiometry in real-world applications is important to note, so that it does not seem to be simply an exercise done only by chemists. [EK 3.A.2] Synthesis reactions are those in which atoms and/or molecules combine to form a new compound. Decomposition is the reverse of synthesis, a process whereby molecules are decomposed, often by the use of heat. [EK 3.B.1] Skill Translate among macroscopic observations of change, chemical equations, and particle views. [LO 3.1, SP 1.5, SP 7.1] Translate an observed chemical change into a balanced chemical equation, and justify the choice of equation type (molecular, ionic, or net ionic) in terms of utility for the given circumstances. [LO 3.2, SP.5, SP7.1] Use stoichiometric calculations to predict the results of performing a reaction in the laboratory and/or to analyze deviations from the expected results. [LO 3.3, SP 2.2, SP 5.1] Relate quantities (measured mass of substances, volumes of solutions, or volumes and pressures of gases) to identify stoichiometric relationships for a reaction, including situations involving limiting reactants and situations in which the reaction has not gone to completion. [LO 3.4, SP 2.2, SP 5.1, SP 6.4]
EVIDENCE OF STUDENT LEARNING	
Formative Performance Task:	You will write lab reports based on the data that they collected which includes a graph and calculations used to determine the stoichiometric relationship, and the balanced equation for the reaction. It is important for students to understand the underlying principle of limiting reactants before we proceed.

	Ladies and Gentlemen today you will work in groups to trace the silver that was recovered back to the original alloy. You will perform the necessary calculation to determine the composition of the alloy and describe the process in a nonmathematical method. You may use pictures, graphs, etc. Error analyses must be incorporated in their reports.
Summative Performance Task:	Students will take a unit exam that emphasizes stoichiometric principles and nomenclature. The underlying theme of particles reacting is also assessed. Students are asked to draw a particle model of a reaction.
Formal Evidence of Learning & Progress:	Written Responses Quiz Test Examinations of Student Work
Informal Evidence of Learning & Progress:	Exit Cards Reading Assessments (Oral, etc.) Pre-Assessments Checklists Peer Review Informal Observations/Dialogues Think A-louds Self-Assessment /Reflection

LEARNING PLAN

Required Activities:	How will we hook (Introduce this to) the students? How will we pre-assess student knowledge, understanding and skills to inform instruction? ...Focus Activity ...How will we organize the sequence of learning? (please include the sequence)
Required Resources:	How will we equip students for expected performances?
Suggested Activities:	Suggested learning activities that will allow students to successfully complete the assessment activities described in Section II. The activities should include 21st Century Skills, technology integration and, where

	relevant, cross-curricular references.
Suggested Resources:	Websites, books, video, etc.
Strategies for Differentiation:	Differentiating content, process, and/or product, using variables of student readiness, interest, and learning style. Examples include: Readiness: small-group instruction, homework options, tiered assessments, compacting, multiple-entry points Interest: choices of books, homework options, explorations by interest and modes of expression (artistic, technological, written, oral, community service) Learning Style: organizational options, working choice options, flexible environment, Multiple Intelligences options

Unit 3

Unit #3:	Internal Structure of the atom
Suggested Timeframe:	13 Days
Subject/Topic:	Laboratory Investigations: Identifying the Elements Using the Bright Line Spectrum (guided inquiry) Radioactivity

DESIRED RESULTS	
Established Goals:	Science Practices: 5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. 5.1.12.B.3: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. 5.1.12.B.4: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. 5.1.12.D.1: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. 5.1.12.D.2: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. 5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. Physical Science: 5.2.12.A.1: Use atomic models to predict the behaviors of atoms in interactions. 5.2.12.A.3: Predict the placement of unknown elements on the Periodic Table based on their physical and chemical properties. 5.2.12.A.4: Explain how the properties of isotopes, including half-lives, decay modes, and nuclear resonances, lead to useful applications of isotopes. 5.2.12.B.1: Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form. 5.2.12.C.2: Account for any trends in the melting points and boiling points of various compounds. Technology: 8.1.12.A.1: Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results. 8.1.12.C.1: Develop an innovative solution to a complex, local or global problem or issue in collaboration with peers and experts, and present ideas for feedback in an online community. 21st Century Life & Career: 9.1.12.A.1: Apply critical thinking and problem-solving strategies during structured learning experiences.

	9.1.12.B.1: Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. 9.1.12.C.4: Demonstrate leadership and collaborative skills when participating in online learning communities and structured learning experiences. 9.1.12.C.5: Assume a leadership position by guiding the thinking of peers in a direction that leads to successful completion of challenging task or project
Enduring Understandings:	The atoms of each element have unique structures arising from interactions between electrons and nuclei. [EU 1.B] Elements display periodicity in their properties when the elements are organized according to increasing atomic number. This periodicity can be explained by the regular variations that occur in the electronic structures of atoms. [EU 1.C] Periodicity is a useful principle for understanding properties and predicting trends in properties. Its modern-day uses range from examining the composition of materials to generating ideas for designing new materials. [EU 1.C] Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms. [EU
Essential Questions:	How does Coulomb's Law explain the structure of the atom and the periodic trends? What data can be collected that give insight into the internal structure of the atom? How can the quantum mechanical model of energy levels in conjunction with Coulomb's Law explain the periodic trends?
Critical Vocabulary	Electromagnetic radiation, wavelength, frequency, Planck's constant, Coulomb's law, quantum, Quantum Mechanical Model, Ground state, Excited state, Heisenberg Uncertainty Principle, Periodic Trends, Atomic radius, Ionic radius, Ionization energies, Electronegativity, Electron shielding, Electron configuration, Energy level,
All Students Will Know and Be Able To. . .	The atom is composed of negatively charged electrons, which can leave the atom, and a positively charged nucleus that is made of protons and neutrons. The attraction of the electrons to the nucleus is the basis of the structure of the atom. Coulomb's law is qualitatively useful for understanding the structure of the atom. [EK 1.B.1] The electronic structure of the atom can be described using an electron configuration that reflects the concept of electrons in quantized energy levels or shells; the energetics of the electrons in the atom can be understood by consideration of Coulomb's law. [EK 1.B.2]

	Many properties of atoms exhibit periodic trends that are reflective of the periodicity of electronic structure. [EK 1.C.1] The currently accepted best model of the atom is based on the quantum mechanical model. [EK 1.C.2] As is the case with all scientific models, any model of the atom is subject to refinement and change in response to new experimental results. In that sense, an atomic model is not regarded as an exact description of the atom, but rather a theoretical construct that fits a set of experimental data. [EK 1.D.1] An early model of the atom stated that all atoms of an element are identical. Mass spectrometry data demonstrate evidence that contradicts this early model. [EK 1.D.2] The interaction of electromagnetic waves or light with matter is a powerful means to probe the structure of atoms and molecules, and to measure their concentration. [EK 1.D.3] **Skills** Predict and/or justify trends in atomic properties based on location on the periodic table and/or the shell model. [LO 1.9, SP 6.4] Justify with evidence the arrangement of the periodic table and apply periodic properties to chemical reactivity. [LO 1.10, SP 6.1] Explain the distribution of electrons in an atom or ion based upon data. [LO 1.5, SP 1.5, SP 6.2] Analyze data relating to electron energies for patterns and relationships. [LO 1.6, SP 5.1] Explain the distribution of electrons using Coulomb's Law to analyze measured energies. [LO 1.8, SP 6.2] Justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. [LO 1.15, SP 4.1, SP 6.4] Describe the electronic structure of the atom, using PES data, ionization energy data, and/or Coulomb's Law to construct explanations of how the energies of electrons within shells in atoms vary. [LO 1.7, SP 5.1, SP 6.2] Explain why a given set of data suggests, or does not suggest, the need to refine the atomic model from a classical shell model with the quantum mechanical model. [LO 1.12, SP 6.3]

	Given information about a particular model of the atom, determine if the model is consistent with specified evidence. [LO 1.13, SP 5.3
EVIDENCE OF STUDENT LEARNING	
Formative Performance Task:	You will use the chrome books (or another video-creating program) to create an explanation of their understanding of Coulomb's Law. Specifically, you will demonstrate your conceptual understanding of what happens to the force when the distance changes between the charged particles, and how the change in the magnitude of the charge changes the magnitude of the force as well. You will have one day to complete your vodcastts, the following day they will be shown to the class for peer assessment using a rubric. You will practice the content and skills involved in connecting the Bohr model to data relating to electron energies and periodic trends using the following assessments: • Wavelength and Frequency: Today you will apply the formula $c = v \cdot \lambda$ to calculate the wavelength and frequency pertaining to electromagnetic radiation. • Bohr and Energy Levels: Today you will apply the formula $E_n = -2.18 \times 10^{-18}(1^2/n^2)$ to calculate the energy released or absorbed as electrons transition between energy levels in the hydrogen atom. Today you will work in groups to generate an explanation of how the quantum mechanical model builds upon the Bohr model of the atom. You will connect the data that allowed for such a revision of the Bohr model into the quantum mechanical model. You will also ensure that your explanation relates to our current use of electron configurations to describe the structure of an atom and explain how older models for atomic structure needed to be refined based on given limitations for each model Ladies and Gentlemen please use the following assessments to practice the content and skills related to reasoning about and identifying periodic trends: • Atomic Radius Trend: You will answer concept questions regarding their knowledge of the atomic radius trend. • Ion Radius Trend: You will answer concept questions regarding their knowledge of the ion radius trend. • Ionization Energy Trend: You will answer concept questions regarding their knowledge of the ionization energy trend. • You will answer concept questions regarding your knowledge of the trends and explain the reason behind each trend using Z (effective charge), energy levels, electron shielding, and Coulomb's Law to justify your reasoning
Summative Performance Task:	In this 30-minute, mid-unit quiz, students will answer 10 multiple-choice questions and one free-response question. The multiple-choice questions focus on the quantum mechanical model and Coulomb's Law. The free-response question focuses on Bohr's model and how it changes for elements with more than one proton

	In this 55-minute assessment, students will answer 14 multiple-choice questions and two free-response questions. The multiple-choice questions focus on the quantum mechanical model, Coulomb's Law, periodic trends, and types of bonds. The first free-response question focuses on periodic trends and analyzing data, and the second focuses on calculations of energy, frequency, and wavelength. Students are asked to explain the differences in values of energy using Coulomb's Law
Formal Evidence of Learning & Progress:	Exit Cards Presentations Written Responses Essays Quizzes Tests Lab reports Checklists Examinations of Student Work
Informal Evidence of Learning & Progress:	Exit Cards Presentations Reading Assessments (Oral, etc.) Pre-Assessments Portfolios Journals Checklists Peer Review Informal Observations/Dialogues Think A-louds Examinations of Student Work Self-Assessment /Reflection

LEARNING PLAN

Required Activities:	Hook – Demo – The Flame test Pre-assess – Q & A Focus Activities

	Lab experiments Problem sets - Text book - Handouts Online quizzes
Required Resources:	Read Text – Chemistry Zumdahl Zumdahl DeCoste 10th Edition View video clips Discussions Websites – Cengage Learning online.
Suggested Activities:	Lab experiments – 1 period experiments Problem sets Kahn Academy Discussions
Suggested Resources:	Websites, books, video clips,
Strategies for Differentiation:	Differentiating content, process, and/or product, using variables of student readiness, interest, and learning style. Readiness: small-group instruction, homework, compacting, multiple-entry points, books, homework options, explorations by interest and modes of expression (artistic, technological, written, oral, community service) Learning Style: organizational options, working choice options, flexible environment, Multiple Intelligences options

Unit 4

Unit #4:	Bonding
Suggested Timeframe:	22 Days
Subject/Topic:	Ionic Bonding Covalent Bonding Metallic Bonding
DESIRED RESULTS	
Established Goals:	Science Practices: 5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. 5.1.12.B.1: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. 5.1.12.B.3: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. 5.1.12.D.1: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. 5.1.12.D.2: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. 5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. Physical Science: 5.2.12.A.1: Use atomic models to predict the behaviors of atoms in interactions. 5.2.12.A.3: Predict the placement of unknown elements on the Periodic Table based on their physical and chemical properties. 5.2.12.B.1: Model how the outermost electrons determine the reactivity of elements and the nature of the chemical bonds they tend to form

	Technology: 8.1.12.A.1: Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results. 8.1.12.C.1: Develop an innovative solution to a complex, local or global problem or issue in collaboration with peers and experts, and present ideas for feedback in an online community. 21st Century Life & Career: 9.1.12.A.1: Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.B.1: Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. 9.1.12.C.4: Demonstrate leadership and collaborative skills when participating in online learning communities and structured learning experiences. 9.1.12.C.5: Assume a leadership position by guiding the thinking of peers in a direction that leads to successful completion of a challenging task or project.
Enduring Understandings:	Atoms are so small that they are difficult to study directly; atomic models are constructed to explain experimental data on collections of atoms. [EU 1.D] Matter can be described by its physical properties. The physical properties of a substance generally depend on the spacing between the particles (atoms, molecules, ions) that make up the substance and the forces of attraction among them. [EU 2.A] Forces of attraction between particles (including the noble gases and also different parts of some large molecules) are important in determining many macroscopic properties of a substance, including how the observable physical state changes with temperature. [EU .B] The strong electrostatic forces of attraction holding atoms together in a unit are called chemical bonds. [EU 2.C] Chemical and physical transformations may be observed in several ways and typically involve a change in energy. [EU 3.C]
Essential Questions:	What models help us to understand the differences between ionic, covalent, and metallic bonding? How do we use Lewis diagrams and the VSEPR model to help predict the geometry, hybridization, polarity, and intermolecular forces of molecules?
Critical Vocabulary	Chap 8&9 Mass spectrometry, Bond energy, Ionic bond, Ionic compound, Coulomb’s Law, Bond length, Covalent

	bonding, Polar covalent bond, Dipole, Dipole moment, isoelectronic ions, Lattice energy, Single bond, Double bond, Triple bond, Lone pair, Bonding pair, Lewis structure, Duet Rule, Octet Rule, Resonance, Resonance structure, Formal charge, Molecular structure, Valence Shell Electron Pair Repulsion Theory (VSEPR), Geometry, Hybridization, Sigma bond, Pi bond, Molecular orbital model, Diamagnetism, Paramagnetism,
All Students Will Know and Be Able To. . .	An early model of the atom stated that all atoms of an element are identical. Mass spectrometry data demonstrate evidence that contradicts this early model. [EK 1.D.2] The interaction of electromagnetic waves or light with matter is a powerful means to probe the structure of atoms and molecules, and to measure their concentration. [EK 1.D.3] Solutions are homogenous mixtures in which the physical properties are dependent on the concentration of the solute and the strengths of all interactions among the particles of the solutes and solvent. [EK2.A.3] Dipole forces result from the attraction among the positive ends and negative ends of polar molecules. Hydrogen bonding is a strong type of dipole-dipole force that exists when very electronegative atoms (N, O, and F) are involved. [EK 2.B.2] In covalent bonding, electrons are shared between the nuclei of two atoms to form a molecule or polyatomic ion. Electronegativity differences between the two atoms account for the distribution of the shared electrons and the polarity of the bond. [EK 2.C.1] The localized electron bonding model describes and predicts molecular geometry using Lewis diagrams and the VSEPR model. [EK 2.C.4] Production of heat or light, formation of a gas, and formation of a precipitate and/or a color change are possible evidences that a chemical change has occurred. [EK 3.C.1] Skills Predict the type of bonding present between two atoms in a binary compound based on position in the periodic table and the electronegativity of the elements. [LO 2.17, SP 6.4] Rank and justify the ranking of bond polarity on the basis of the locations of the bonded atoms in the periodic table. [LO 2.18, SP 6.1] Use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about

	polarity. [LO 2.21,SP 1.4] Describe the relationships between the structural features of polar molecules and the forces of attraction between the particles. [LO 2.13, SP 1.4, SP 6.4] Use Lewis diagrams and VSEPR to predict the geometry of molecules, identify hybridization, and make predictions about polarity. [LO 2.21, SP 1.4] Explain how solutes can be separated by chromatography based on intermolecular interactions. [LO 2.7, SP 6.2] Design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components. [LO 2.10, SP 4.2, SP 5.1, SP 6.4] Evaluate the classification of a process as a physical change, chemical change, or ambiguous change based on both macroscopic observations and the distinction between rearrangement of covalent interactions and non-covalent interactions. [LO 3.10, SP 1.4, SP 6.1, connects to 5.D.2] Design and/or interpret the results of a separation experiment (filtration, paper chromatography, column chromatography, or distillation) in terms of the relative strength of interactions among and between the components. [LO 2.10, SP 4.2, SP 5.1, SP 6.4] Design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution. [LO 1.16, SP 4.2, SP 5.1] Justify the selection of a particular type of spectroscopy to measure properties associated with vibrational or electronic motions of molecules. [LO 1.15, SP 4.1, SP 6.4]
EVIDENCE OF STUDENT LEARNING	
Formative Performance Task:	Using the following assessments to practice the content and skills learned in previous activities: • Ionic Compound Properties: Please answer the following multiple-choice questions about properties of ionic compounds. • Type I Nomenclature: Please answer the following short-answer questions focus on Type I Nomenclature.

	• Type II Nomenclature: Please answer the following short-answer questions focusing on Type II Nomenclature. • Type I and II Nomenclature: Please answer the following short-answer questions focus on a mixture of nomenclature and polyatomic ions. • Today you will analyze and draw lattice structures of ionic compounds and justify the properties of ionic compounds, comparing and contrasting them with metal properties. Responses are evaluated by peers using a rubric. Using the following assessments to practice the content and skills learned in previous activities: • Type III Nomenclature: Please answer the following short-answer questions focus on naming covalent compounds. •Type I, II, and III Nomenclature: Please answer the following short-answer questions focus on naming a mixture of ionic and covalent compounds. Lewis Structures Activity Lab: Today, we will be making models of molecules and polyatomic ions, then drawing Lewis dot structures, describe the molecular geometry, and predict their polarity using VSEPR theory. We will predict the intermolecular forces between like molecules as well as other molecules within the list of molecules they will create using the molecule-building kit. Identifying Unknowns by Connecting Macroscopic Observations to Intermolecular Forces (guided-inquiry lab): Pre- and post-lab questions focus on evaluating students' particulate-level reasoning pertaining to intermolecular forces by contrasting the characteristics of molecular and covalent solids and translating between particulate views and macroscopic characteristics. Some questions also focus on contrasting the differences between metal, ionic solids, molecular solids, and covalent solids. Students are expected to correctly identify the unknown solids in the lab and to justify their identifications with evidence from a series of tests performed to uncover macroscopic properties and identify intermolecular forces associated with the unknown substances. After practicing the writing of chemical equations in the previous instructional activity, students are shown several reaction demonstrations, make observations, and write balanced chemical equations (using and justifying the most appropriate equation type) based on the observed demonstrations. You will use the internet to practice the content and skills related to identifying and representing a process as a chemical or physical change through explanations and drawings of inter- and intramolecular forces:

	Ladies & Gentlemen today you will be answering questions focusing on one's ability to analyze inter-particle relationships in physical and chemical changes. You will draw and explain the particle-level interactions to identify whether a change is chemical or physical. We will use peer-evaluations to evaluate one another's responses based on a rubric
Summative Performance Task:	In this 55-minute assessment, students answer 20 multiple-choice questions and two free-response questions. The multiple-choice questions focus on conceptual questions regarding ionic, covalent, and metallic bonds. They also cover reactions and conservation of matter. The first free-response question focuses on Lewis structures, molecular shapes, polarity, and intermolecular forces. The second free-response question focuses on drawing and justifying the similarities and differences between the properties of ionic, metallic, and covalent solids. Students must be able to explain how the microscopic inter-particle interactions lead to the macroscopic properties observed during chemical reactions.
Formal Evidence of Learning & Progress:	Exit Cards Presentations Written Responses Essays Quizzes Tests Research Projects Portfolios Lab reports Checklists Examinations of Student Work
Informal Evidence of Learning & Progress:	Exit Cards Presentations Reading Assessments (Oral, etc.) Pre-Assessments Portfolios Journals Checklists Peer Review Informal Observations/Dialogues Think A-louds Examinations of Student Work Self-Assessment /Reflection Add Other

LEARNING PLAN	
Required Activities:	Hook – Video on bonding. Pre-assess – Q & A, KWL Focus Activities Lab experiments Problem sets - Text book - Handouts - Online quizzes
Required Resources:	Read Text – Chemistry Zumdahl Zumdahl DeCoste 10^{th} Edition View video clips Discussions Websites – Cengage Learning online
Suggested Activities:	Additional Experiments Discussions Additional Video clips
Suggested Resources:	Websites, additional books, video,
Strategies for Differentiation:	Readiness: small-group instruction, homework, compacting, multiple-entry points, books, homework options, explorations by interest and modes of expression (artistic, technological, written, oral, community service) Learning Style: organizational options, working choice options, flexible environment, Multiple Intelligences options

Unit 5

Unit #5:	Thermochemistry and Gas Laws
Suggested Timeframe:	12 Days
Subject/Topic:	Laboratory Inquiry - Determine the molar enthalpy of a neutralization reaction between sodium hydroxide and hydrochloric acid - Determine the specific heat of an unknown metal.
DESIRED RESULTS	
Established Goals:	Science Practices: 5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. 5.1.12.B.1: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. 5.1.12.B.2: Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. 5.1.12.B.3: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. 5.1.12.B.4: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. 5.1.12.D.1: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. 5.1.12.D.2: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. 5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. Physical Science: 5.2.12.A.1: Use atomic models to predict the behaviors of atoms in interactions. 5.2.12.D.2: Describe the potential commercial applications of exothermic and endothermic reactions.

	Technology: 8.1.12.A.1: Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results. 8.1.12.C.1: Develop an innovative solution to a complex, local or global problem or issue in collaboration with peers and experts, and present ideas for feedback in an online community. 21st Century Life & Career: 9.1.12.A.1: Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.B.1: Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. 9.1.12.C.4: Demonstrate leadership and collaborative skills when participating in online learning communities and structured learning experiences. 9.1.12.C.5: Assume a leadership position by guiding the thinking of peers in a direction that leads to successful completion of a challenging task or project.
Enduring Understandings:	Two systems with different temperatures that are in thermal contact will exchange energy. The quantity of thermal energy transferred from one system to another is called heat. [5.A] Chemical and physical transformations may be observed in several ways and typically involve a change in energy. [EU 3.C] Energy is neither created nor destroyed, but only transformed from one form to another. [EU 5.B] Breaking bonds requires energy, and making bonds releases energy. [EU 5.C] Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy. [EU 5.D] Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both. [EU 5.E]]
Essential Questions:	We can model the motion of gases as individual particles. When does the model most accurately represent nature? When a scuba diver stays underwater for an extended time and then surfaces quickly, he or she may experience the bends. What are the cause and the cure?

	Why do some packaged foods have different cooking instructions for different locations? How does energy play a role in bonding, phase changes, and heat transfers? What models do chemists use to visualize particles in the solid, liquid, and gas phases?
Critical Vocabulary	Barometer, Manometer, mmHg, Pascal, Atm, Torr, Boyle's Law, Charles Law, Combined Gas Law, Ideal Gas Law, Ideal gas, Absolute zero, Avogadro's Law, Universal gas constant, Molar volume, Standard Temperature and Pressure (STP), Dalton's Law of Partial Pressure, Mole fraction, Kinetic Molecular Theory (KMT), Joule, Real gas, Air pollution, atmosphere, acid rain, photochemical smog, Energy, Law of conservation of energy, Potential energy, Kinetic energy, Heat, Work, Exothermic, Endothermic, Thermodynamics, Enthalpy, Calorimetry, Calorimeter, Specific heat capacity, Molar heat capacity, Hess's law, Greenhouse effect
All Students Will Know and Be Able To. . .	Temperature is a measure of the average kinetic energy of atoms and molecules. [5.A.1] The gaseous state can be effectively modeled with a mathematical equation relating various macroscopic properties. A gas has neither a definite volume nor a definite shape; because the effects of attractive forces are minimal, we usually assume that the particles move independently. [2.A.2] The mole is the fundamental unit for counting numbers of particles on the macroscopic level and allows quantitive connections to be drawn between laboratory experiments, which occur at the macroscopic level, and chemical processes, which occur at the atomic level.[1.A.3] Net changes in energy for a chemical reaction can be endothermic or exothermic. [EK 3.C.2] The process of kinetic energy transfer at the particulate scale is referred to in this course as heat transfer, and the thermodynamically favored direction of the transfer is always from a hot to a cold body. [EK 5.A.2] Energy is transferred between systems either through heat transfer or through one system doing work on the other system. [EK 5.B.1] When two systems are in contact with each other and are otherwise isolated, the energy that comes out of one system is equal to the energy that goes into the other system. The combined energy of the two systems remains fixed. Energy transfer can occur through either heat exchange or work. [EK 5.B.2]

	Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions. [EK 5.B.3] Calorimetry is an experimental technique that is used to determine the heat exchanged/transferred in a chemical system. [EK 5.B.4] The net energy change during a reaction is the sum of the energy required to break the bonds in the reactant molecules and the energy released in forming the bonds of the product molecules. The net change in energy may be positive for endothermic reactions where energy is required, or negative for exothermic reactions where energy is released. [EK 5.C.2] Potential energy is associated with the interaction of molecules; as molecules draw near each other, they experience an attractive force. [EK 5.D.1] Entropy is a measure of the dispersal of matter and energy. [EK 5.E.1] Skills Connect the number of particles, moles, mass, and the volume of substances to one another, both qualitatively and quantitatively. [LO 1.4, SP 7.1] Refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample. [LO 2.5, SP 1.3, SP 6.4, SP 7.2] Apply mathematical relationships or estimation to determine macroscopic variables for ideal gases. [LO 2.6, SP 2.2, SP 2.3] Refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample. [LO 2.5, SP 1.3, SP 6.4, SP 7.2] Refine multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes in macroscopic properties on the sample. [LO 2.5, SP 1.3, SP 6.4, SP 7.2] Apply mathematical relationships or estimation to determine macroscopic variables for ideal gases. [LO 2.6, SP 2.2, SP 2.3]

	Use Kinetic Molecular Theory and the concepts of intermolecular forces to make predictions about the macroscopic properties of gases, including both ideal and non-ideal behaviors. [LO 2.4, SP 1.4, SP 6.4] Qualitatively analyze data regarding real gases to identify deviations from ideal behavior and relate these to molecular interactions. [LO 2.12, SP 5.1, SP 6.5, connects to 2.A.2] Relate temperature to the motions of particles, either via particulate representations, such as drawings of particles with arrows indicating velocities, and/or via representations of average kinetic energy and distribution of kinetic energies of the particles, such as plots of the Maxwell-Boltzmann distribution. [LO 5.2, SP 1.1, SP 1.4, SP 7.1] Design and/or interpret the results of an experiment in which calorimetry is used to determine the change in enthalpy of a chemical process (heating/cooling, phase transition, or chemical reaction) at constant pressure. [LO 5.7, SP 4.2, SP 5.1, SP 6.4] Generate explanations or make predictions about the transfer of thermal energy between systems based on this transfer being due to a kinetic energy transfer between systems arising from molecular collisions. [LO 5.3, SP 7.1] Use conservation of energy to relate the magnitudes of the energy changes occurring in two or more interacting systems, including identification of the systems, the type (heat versus work), or the direction of energy flow. [LO 5.4, SP 1.4, SP 2.2, connects to 5.B.1, 5.B.2] Use conservation of energy to relate the magnitudes of the energy changes when two non-reacting substances are mixed or brought into contact with one another. [LO 5.5, SP 2.2, connects to 5.B.1, 5.B.2] Draw qualitative and quantitative connections between the reaction enthalpy and the energies involved in the breaking and formation of chemical bonds. [LO 5.8, SP 2.3, SP 7.1, SP 7.2] Use calculations or estimations to relate energy changes associated with heating/cooling a substance to the heat capacity, relate energy changes associated with a phase transition to the enthalpy of fusion/vaporization, relate energy changes associated with a chemical reaction to the enthalpy of the reaction, and relate energy changes to $P\Delta V$ work. [LO 5.6, SP 2.2, SP 2.3] Analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and

	representations. [LO 6.24, SP 1.4, SP 7.1, connects to 5.E]
EVIDENCE OF STUDENT LEARNING	
Formative Performance Task:	Here are four short free-response questions based on the Molecular Mass of a Volatile Liquid lab. You will work in groups of twos and then we will come together to discuss the responses and the purpose of the activity. One of the questions request a description of the model of a gas. I am giving a short quiz covering the ideal gas law, unit conversions, and the techniques used in the Molecular Mass of a Volatile Liquid lab. After conducting the experiment you are required to write lab reports in which the kinetic molecular theory is addressed. You are asked to describe a model of a gas and then to answer questions related to that model. We will discuss individual responses as a class Using the internet, you will make observations pertaining to different phases and how the particles move differently in those phases. You will also draw conclusions regarding the macroscopic observations based on the microscopic analysis of simulations found. You will analyze multiple representations of a sample of matter in the gas phase to accurately represent the effect of changes such as temperature, pressure, and volume in macroscopic properties of the gas. You will also observe macroscopic observations of gases and must draw associated particulate representations of such interactions (pertaining to intermolecular forces) between the gas molecules. • Gas Laws: You will calculate for unknown variables using the appropriate gas laws. • Ideal Gas Law and Gas Stoichiometry: You will apply the Ideal gas law to solve problems requiring stoichiometry. • Pressure and Volume (PV) Diagrams: You will answer concept questions, solve problems analyzing the PV diagram of a gas, and calculate the work done Here is a take-home exam and associated rubric that covers the concepts of the entire unit. You will have two days to complete this exam. We will meet after the exam has been graded to go over them.

Summative Performance Task:	In-class exam (timed: 60 minutes) consisting of multiple-choice and free-response questions. Part of the assessment poses different models of gases to the students. Students change the values of the P, V, and T variables to examine the effects of each change on the model. Another part will cover thermodynamics.
Formal Evidence of Learning & Progress:	Exit Cards Presentations Written Responses Essays Quizzes Tests Research Projects Portfolios Lab report Checklists Examinations of Student Work
Informal Evidence of Learning & Progress:	Exit Cards Presentations Reading Assessments (Oral, etc.) Pre-Assessments Portfolios Journals Checklists Peer Review Informal Observations/Dialogues Think A-louds Examinations of Student Work Self-Assessment /Reflection

LEARNING PLAN

Required Activities:	Hook – Propane bubbles Pre-assess - KWL Focus Activity

	- Experiments - Problem sets - Discussion,
Required Resources:	Read Text – Chemistry Zumdahl Zumdahl DeCoste 10^{th} Edition View video clips Discussions Websites – Cengage Learning online
Suggested Activities:	.Lab experiments – 1 period experiments Problem sets Kahn Academy
Suggested Resources:	Websites, books, video, etc.
Strategies for Differentiation:	Small-group instruction, homework options, tiered assessments, compacting, multiple-entry points Interest: choices of books, homework options, explorations by interest and modes of expression (artistic, technological, written, oral, community service) Learning Style: organizational options, working choice options, flexible environment, Multiple Intelligences options

Unit 6

Unit #6:	Kinetics
Suggested Timeframe:	13 Days
Subject/Topic:	Factors that affect rates of reactions
DESIRED RESULTS	
Established Goals:	Science Practices: 5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. 5.1.12.B.1: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. 5.1.12.B.2: Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. 5.1.12.B.3: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. 5.1.12.B.4: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. 5.1.12.D.1: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. 5.1.12.D.2: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. 5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. Physical Science: 5.2.12.A.1: Use atomic models to predict the behaviors of atoms in interactions. 5.2.12.C.1: Use the kinetic molecular theory to describe and explain the properties of solids, liquids, and gases. 5.2.12.D.5: Model the change in rate of a reaction by changing a factor.

	5.2.12.E.1: Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values. Technology: 8.1.12.A.1: Construct a spreadsheet, enter data, and use a mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results. 8.1.12.C.1: Develop an innovative solution to a complex, local or global problem or issue in collaboration with peers and experts, and present ideas for feedback in an online community. 21st Century Life & Career: 9.1.12.A.1: Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.B.1: Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. 9.1.12.C.4: Demonstrate leadership and collaborative skills when participating in online learning communities and structured learning experiences. 9.1.12.C.5: Assume a leadership position by guiding the thinking of peers in a direction that leads to successful completion of a challenging task or project.
Enduring Understandings:	Reaction rates that depend on temperature and other environmental factors are determined by measuring changes in concentrations of reactants or products over time. [EU 4.A] Elementary reactions are mediated by collisions between molecules. Only collisions having sufficient energy and proper relative orientation of reactants lead to products. [EU 4.B] Many reactions proceed via a series of elementary reactions. [EU4.C] Reaction rates may be increased by the presence of a catalyst. [EU 4.B]
Essential Questions:	The stoichiometry and the kinetics of a reaction are determined from laboratory investigations. How is a mechanism determined? When two different collisions occur between two particles, why does only one result in the formation of a product? A chemical engineer needs to remove hydrogen peroxide from a solution. What would be the advantages and disadvantages of using a heterogeneous catalyst over a homogeneous catalyst?

Critical Vocabulary	Chemical kinetics, Reaction rate, Rate Law, Rate constant, Rate order, integrated rate law, initial rate, overall reaction order, First order, Zero order, Second order, Half-life, Integrated first order, Integrated zero order, Integrated second order, Reaction mechanism, Rate-determining step, Collision model, Activation energy, Arrhenius equation, Enzyme, Catalyst, Heterogeneous catalyst, Homogeneous catalyst
All Students Will Know and Be Able To. . .	The rate of a reaction is influenced by the concentration or pressure of reactants, the phase of the reactants and products, and environmental factors such as temperature and solvent. [EK 4.A.1] The rate law shows how the rate depends on reactant concentrations. [EK4.A.2] The magnitude and temperature dependence of the rate of reaction is contained quantitatively in the rate constant. [EK 4.A.3] Elementary reactions can be unimolecular or involve collisions between two or more molecules. [EK4.B.1] Not all collisions are successful. To get over the activation energy barrier, the colliding species need sufficient energy. Also, the orientations of the reactant molecules during the collision must allow for the rearrangement of reactant bonds to form product bonds. [EK4.B.2] A successful collision can be viewed as following a reaction path with an associated energy profile. [EK 4.B.3] The mechanism of a multistep reaction consists of a series of elementary reactions that add up to the overall reaction. [EK 4.C.1] In many reactions, the rate is set by the slowest elementary reaction, or rate-limiting step. [EK 4.C.2] Reaction intermediates, which are formed during the reaction but not present in the overall reaction, play an important role in multistep reactions. [EK4.C.3] Catalysts function by lowering the activation energy of an elementary step in a reaction mechanism, and by providing a new and faster reaction mechanism. [EK 4.D.1] Important classes in catalysis include acid-base catalysis, surface catalysis, and enzyme catalysis. [EK 4.D.2]

	Skills Design and/or interpret the results of an experiment regarding the factors (i.e., temperature, concentration, surface area) that may influence the rate of a reaction. [LO 4.1, SP 4.2, SP 5.1] Analyze concentration vs. time data to determine the rate law for a zeroth-, first-, or second-order reaction. [LO 4.2, SP 5.1, SP 6.4, connects to 4.A.3] Connect the half-life of a reaction to the rate constant of a first-order reaction and justify the use of this relation in terms of the reaction being a first-order reaction. [LO 4.3, SP 2.1, SP 2.2] Connect the rate law for an elementary reaction to the frequency and success of molecular collisions, including connecting the frequency and success to the order and rate constant, respectively. [LO 4.4, SP 7.1, connects to 4.A.3, 4.B.2] Explain the difference between collisions that convert reactants to products and those that do not in terms of energy distributions and molecular orientation. [LO 4.5, SP 6.2] Use representations of the energy profile for an elementary reaction (from the reactants, through the transition state, to the products) to make qualitative predictions regarding the relative temperature dependence of the reaction rate. [LO 4.6, SP 1.4, SP 6.4] Evaluate alternative explanations, as expressed by reaction mechanisms, to determine which are consistent with data regarding the overall rate of a reaction, and data that can be used to infer the presence of a reaction intermediate. [LO 4.7, SP 6.5, connects to 4.C.1, 4.C.2, 4.C.3] Translate among reaction energy profile representations, particulate representations, and symbolic representations (chemical equations) of a chemical reaction occurring in the presence and absence of a catalyst. [LO 4.8, SP 1.5] Explain changes in reaction rates arising from the use of acid-base catalysts, surface catalysts, or enzyme catalysts, including selecting appropriate mechanisms with or without the catalyst present. [LO 4.9, SP 6.2, SP 7.2]
EVIDENCE OF STUDENT LEARNING	
Formative	Today’s experiment is ‘The Iodine Clock Reaction’. After performing the reactions and collected the data you will write a

Performance Task:	lab report. The report will address the order of a reaction and the rate law expression In groups of twos you will answer six short-answer questions related to the lab activity that they performed. Then we will return to class and discusses the data and calculations as a group. Having performed the Iodine Clock Reaction you will divide into groups of twos and propose a mechanism for the reaction. We will then return to class and examine the mechanisms and identify the most logical ones You will be given a take-home exam and associated rubric that covers the concepts of the entire unit. You will have two days to complete this exam. After I have graded the exam we will meet to correct/explain any misconceptions.
Summative Performance Task:	In-class exam (timed: 80 minutes) consisting of multiple-choice and free-response questions are posed pertaining to chemical reactions, rates of reaction, kinetic molecular theory, and molecular collisions.
Formal Evidence of Learning & Progress:	Exit Cards Presentations Written Responses Essays Quizzes Tests Research Projects Portfolios Journals Checklists Examinations of Student Work
Informal Evidence of Learning & Progress:	Exit Cards Presentations Reading Assessments (Oral, etc.) Pre-Assessments Portfolios Journals Checklists Peer Review Informal Observations/Dialogues

	Think A-louds Examinations of Student Work Self-Assessment /Reflection
LEARNING PLAN	
Required Activities:	Hook Video on Rates of Reaction KWL Focus Activity - Experiments - Problem sets - Discussion Problem sets - Text book - Handouts - Online quizzes
Required Resources:	Read Text – Chemistry Zumdahl Zumdahl DeCoste 10th Edition View video clips Discussions Websites – Cengage Learning online
Suggested Activities:	Lab experiments – 1 period experiments Problem sets Kahn Academy
Suggested Resources:	Websites, books, video,
Strategies for Differentiation:	Differentiating content, process, and/or product, using variables of student readiness, interest, and learning style. Examples include:

	Readiness: small-group instruction, homework options, tiered assessments, compacting, multiple-entry points Interest: choices of books, homework options, explorations by interest and modes of expression (artistic, technological, written, oral, community service) Learning Style: organizational options, working choice options, flexible environment, Multiple Intelligences options

Unit 7

Unit #7:	Equilibrium
Suggested Timeframe:	30 Days
Subject/Topic:	Deterring the factors that will cause s shift in an equilibrium reaction Connecting the structure of an acid or base to the resulting pH of the solution Designing and testing effective buffers
DESIRED RESULTS	
Established Goals:	Science Practices: 5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanations. 5.1.12.B.1: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. 5.1.12.B.2: Build, refine, and represent evidence-based models using mathematical, physical, and computational tools. 5.1.12.B.3: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. 5.1.12.B.4: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. 5.1.12.D.1: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. 5.1.12.D.2: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. 5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. Physical Science: 5.2.12.A.2: Account for the differences in the physical properties of solids, liquids, and gases. 5.2.12.B.3: Balance chemical equations by applying the law of conservation of mass. 5.2.12.E.1: Compare the calculated and measured speed, average speed, and acceleration of an object in motion, and account for differences that may exist between calculated and measured values.

	Technology: 8.1.12.A.1: Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results. 8.1.12.C.1: Develop an innovative solution to a complex, local or global problem or issue in collaboration with peers and experts, and present ideas for feedback in an online community. 21st Century Life & Career: 9.1.12.A.1: Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.B.1: Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. 9.1.12.C.4: Demonstrate leadership and collaborative skills when participating in online learning communities and structured learning experiences. 9.1.12.C.5: Assume a leadership position by guiding the thinking of peers in a direction that leads to successful completion of a challenging task or project
Enduring Understandings:	Chemical equilibrium is a dynamic, reversible state in which rates of opposing processes are equal. [EA 6.A] Systems at equilibrium are responsive to external perturbations, with the response leading to a change in the composition of the system. [EA 6.B] Chemical equilibrium plays an important role in acid-base chemistry and in solubility. [EA 6.C
Essential Questions:	What happens at the microscopic level that helps us understand that concentration, temperature, surface area, and catalysts affect rates of reactions? What are some real-life applications of buffer systems? How does the ocean act as a buffer?
Critical Vocabulary	Chemical equilibrium, equilibrium expression, equilibrium constant (K, Kc, Kp, Keq), homogeneous equilibrium, heterogeneous equilibrium, Reaction quotient (Q), Le Chatelier's Principle, Arrhenius acid, Arrhenius base, Bronsted-Lowry acid, Bronsted-Lowry base, Conjugate acid, Conjugate base, Conjugate acid – base pair, Acid-dissociation constant (Ka), Strong acid, Weak acid, Mono-protic acid, Diprotic acid, poly-protic acid, oxyacid, pH scale, pOH scale, Percent dissociation, Strong base, Weak base, Base –dissociation constant (Kb), Common ion, Common ion effect, Buffered solution, Henderson-Hasselbalch equation, acid-base indicator, Solubility product constant (Ksp), ion product, selective

	precipitation, complex ion Equilibrium constant of water (Kw), Spontaneous process, Non-spontaneous process, Entropy, Second law of thermodynamics, Third law of thermodynamics, Free energy, Standard free energy,
All Students Will Know and Be Able To. . .	In many classes of reactions, it is important to consider both the forward and reverse reaction. [EK 6.A.1] The current state of a system undergoing a reversible reaction can be characterized by the extent to which reactants have been converted to products. The relative quantities of reaction components are quantitatively described by the reaction quotient, Q. [EK 6.A.2] When a system is at equilibrium, all macroscopic variables, such as concentrations, partial pressures, and temperature, do not change over time. Equilibrium results from an equality between the rates of the forward and reverse reactions, at which point Q = K. [EK 6.A.3] The magnitude of the equilibrium constant, K, can be used to determine whether the equilibrium lies toward the reactant side or product side. [EK 6.A.4] Systems at equilibrium respond to disturbances by partially countering the effect of the disturbance (Le Chatelier's principle). [EK 6.B.1] A disturbance to a system at equilibrium causes Q to differ from K, thereby taking the system out of the original equilibrium state. The system responds by bringing Q back into agreement with K, thereby establishing a new equilibrium state. [EK 6.B.2] Chemical equilibrium reasoning can be used to describe the proton-transfer reactions of acid-base chemistry. [EK 6.C.1] The pH is an important characteristic of aqueous solutions that can be controlled with buffers. Comparing pH to pKa allows one to determine the protonation state of a molecule with a labile proton. [EK 6.C.2] The solubility of a substance can be understood in terms of chemical equilibrium. [EK 6.C.3] **Skills** construct an explanation that connects the observations to the reversibility of the underlying chemical reactions or processes when given a set of experimental observations regarding

	physical, chemical, biological, or environmental processes that are reversible . [LO 6.1, SP 6.2] Use the tendency of Q to approach K to predict and justify the prediction as to whether the reaction will proceed toward products or reactants as equilibrium is approached when given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K, . [LO 6.4, SP 2.2, SP 6.4] Calculate the equilibrium constant, K when given data (tabular, graphical, etc.) from which the state of a system at equilibrium can be obtained [LO 6.5, SP 2.2] Use stoichiometric relationships and the law of mass action (Q equals K at equilibrium) to determine qualitatively and/or quantitatively the conditions at equilibrium for a system involving a single reversible reaction when given a set of initial conditions (concentrations or partial pressures) and the equilibrium constant, K,. [LO 6.6, SP 2.2, SP 6.4] Determine the effects of that manipulation on Q or K given a manipulation of a chemical reaction or set of reactions (e.g., reversal of reaction or addition of two reactions), determine. [LO 6.2, SP 2.2] Connect kinetics to equilibrium by using reasoning about equilibrium, such as Le Chatelier's principle, to infer the relative rates of the forward and reverse reactions. [LO 6.3, SP 7.2] Use Le Chatelier's principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium. [LO 6.8, SP 1.4, SP 6.4] Use Le Chatelier's principle to design a set of conditions that will optimize a desired outcome, such as product yield. [LO 6.9, SP 4.2] Use Le Chatelier's principle to predict the direction of the shift resulting from various possible stresses on a system at chemical equilibrium. [LO 6.8, SP 1.4, SP 6.4] Connect Le Chatelier's principle to the comparison of Q to K by explaining the effects of the stress on Q and K. [LO 6.10, SP 1.4, SP 7.2] Identify compounds as Bronsted-Lowry acids, bases, and/or conjugate acid-base pairs, using proton-transfer reactions to justify the identification. [LO 3.7, SP 6.1] Generate or use a particulate representation of an acid (strong or weak or polyprotic) and a strong base to explain the

	species that will have large versus small concentrations at equilibrium. [LO 6.11, SP 1.1, SP 1.4, SP 2.3] Reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration. [LO 6.12, SP 1.4, SP 6.4, connects to 1.E.2] Identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species in the solution, and/or infer the relative strengths of the weak acids or bases from given equilibrium concentrations. [LO 6.16, SP 2.2, SP 6.4] Explain the relative strengths of acids and bases based on molecular structure, inter-particle forces, and solution equilibrium. [LO 2.2, SP 7.2, connects to Big Idea 5, Big Idea 6] For a reversible reaction that has a large or small K, determine which chemical species will have very large versus very small concentrations at equilibrium. [LO 6.7, SP 2.2, SP 2.3] Identify a given solution as being the solution of a monoprotic weak acid or base (including salts in which one ion is a weak acid or base), calculate the pH and concentration of all species in the solution, and/or infer the relative strengths of the weak acids or bases from given equilibrium concentrations. [LO 6.16, SP 2.2, SP 6.4] Reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration. [LO 6.12, SP 1.4, SP 6.4, connects to 1.E.2] Identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base. [LO 6.20, SP 6.4] Determine which species will react strongly with one another (i.e., with K >1) and what species will be present in large concentrations at equilibrium when given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems),. [LO 6.17, SP 6.4] Design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity. [LO 6.18, SP 2.3, SP 4.2, SP 6.4

	Identify a solution as being a buffer solution and explain the buffer mechanism in terms of the reactions that would occur on addition of acid or base. [LO 6.20, SP 6.4] Determine which species will react strongly with one another (i.e., with K >1) and what species will be present in large concentrations at equilibrium when given an arbitrary mixture of weak and strong acids and bases (including polyprotic systems). [LO 6.17, SP 6.4] Identify a given solution as containing a mixture of strong acids and/or bases and calculate or estimate the pH (and concentrations of all chemical species) in the resulting solution. [LO 6.15, SP 2.2, SP 2.3, SP 6.4] Interpret titration data for monoprotic or polyprotic acids involving titration of a weak or strong acid by a weak or strong base to determine the concentration of the titrant and the pKa for a weak acid, or the pKb for a weak base. [LO 6.13, SP 5.1, SP 6.4, connects to 1.E.2] Reason about the distinction between strong and weak acid solutions with similar values of pH, including the percent ionization of the acids, the concentrations needed to achieve the same pH, and the amount of base needed to reach the equivalence point in a titration. [LO 6.12, SP 1.4, SP 6.4, connects to 1.E.2] Design a buffer solution with a target pH and buffer capacity by selecting an appropriate conjugate acid-base pair and estimating the concentrations needed to achieve the desired capacity. [LO 6.18, SP 2.3, SP 4.2, SP 6.4] Predict the solubility of a salt, or rank the solubility of salts, given the relevant Ksp values. [LO 6.21, SP 2.2, SP 2.3, SP 6.4] Explain observations regarding the solubility of ionic solids and molecules in water and other solvents on the basis of particle views that include intermolecular interactions and entropic effects. [LO 2.15, SP 1.4, SP 6.2, connects to 5.E.1] Interpret data regarding the relative solubility of salts in terms of factors (common ions, pH) that influence the solubility. [LO 6.23,SP5.1, SP 6.4] Interpret data regarding solubility of salts to determine, or rank, the relevant Ksp values.

	[LO 6.22, SP 2.2, SP 2.3, SP 6.4] Apply Coulomb's Law qualitatively (including using representations) to describe the interactions of ions, and the attractions between ions and solvents to explain the factors that contribute to the solubility of ionic compounds. [LO 2.14, SP 1.4, SP 6.4] Design and/or interpret the results of an experiment regarding the absorption of light to determine the concentration of an absorbing species in a solution. [LO 1.16, SP 4.2, SP 5.1] Analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations. [LO 6.24, SP 1.4, SP 7.1, connects to 5.E]
EVIDENCE OF STUDENT LEARNING	
Formative Performance Task:	Determining the Factors That Will Cause a Shift in an Equilibrium Reaction (guided-inquiry lab): Working in groups you will design a set of procedures using the equipment provided to test and observe Le Chatelier's principle. You will make predictions of the direction the reaction will shift, based on stresses you design for the reaction. Before performing the procedure I will check it for safety. After performing the reactions you will write a lab report which includes your predictions and your results. Students use teacher made assessments and workshop to practice the content and skills learned in preceding activities: • Equilibrium Constant Expressions: You will write equilibrium constant expressions from balanced chemical reactions. • Calculate Equilibrium Constants: You will calculate equilibrium constant expressions from equilibrium concentration and pressure values. • These questions focus on ypur ability to explain the concept of equilibrium from a set of experimental observations regarding physical, chemical, biological, or environmental processes. You will be given a set of problems that require the use of initial conditions, K, and stoichiometric relationships to calculate the concentrations of both products and reactants at equilibrium. You will be given a set of problems that require the use of the internet to practice the content and skills learned in preceding activities:

	• These questions focus on your ability to couple reactions with common intermediates and use Le Chatelier's principle to predict the shift in the coupled reaction.
Summative Performance Task:	In this 30-minute assessment, students answer 10 multiple-choice questions and one free-response question. The multiple-choice questions focus on basics of equilibrium and kinetics. The free-response question focuses on students' ability to calculate both K and Q, compare and contrast the two, and determine in which direction a reaction will shift.
Formal Evidence of Learning & Progress:	Exit Cards Presentations Written Responses Essays Quizzes Tests Research Projects Portfolios Journals Checklists Examinations of Student Work
Informal Evidence of Learning & Progress:	Exit Cards Presentations Reading Assessments (Oral, etc.) Pre-Assessments Portfolios Journals Checklists Peer Review Informal Observations/Dialogues Think A-louds Examinations of Student Work Self-Assessment /Reflection

LEARNING PLAN

Required Activities:	Hook – Shifting the equilibrium using Cobalt (II) chloride, 6molar hydrochloric acid and water. Pre-Assess: Q&A Focus Activity - Experiments - Problem sets - Discussion - Online quizzes
Required Resources:	Read Text – Chemistry Zumdahl Zumdahl DeCoste 10th Edition View video clips Discussions Websites – Cengage Learning online
Suggested Activities:	Lab experiments – 1 period experiments Problem sets Kahn Academy.
Suggested Resources:	Websites, books, video, etc.
Strategies for Differentiation:	Readiness: small-group instruction, homework options, tiered assessments, compacting, multiple-entry points Interest: choices of books, homework options, explorations by interest and modes of expression (artistic, technological, written, oral, community service) Learning Style: organizational options, working choice options, flexible environment, Multiple Intelligences options

Unit 8

Unit #8:	Entropy and Electrochemistry
Suggested Timeframe:	15 Days
Subject/Topic:	Free Energy Applications of redox
DESIRED RESULTS	
Established Goals:	Science Practices: 5.1.12.A.1: Refine interrelationships among concepts and patterns of evidence found in different central scientific explanation. 5.1.12.B.1: Design investigations, collect evidence, analyze data, and evaluate evidence to determine measures of central tendencies, causal/correlational relationships, and anomalous data. 5.1.12.B.2: Build, refine, and represent evidence-based m models using mathematical, physical, and computational tools. 5.1.12.B.3: Revise predictions and explanations using evidence, and connect explanations/arguments to established scientific knowledge, models, and theories. 5.1.12.B.4: Develop quality controls to examine data sets and to examine evidence as a means of generating and reviewing explanations. 5.1.12.D.1: Engage in multiple forms of discussion in order to process, make sense of, and learn from others' ideas, observations, and experiences. 5.1.12.D.2: Represent ideas using literal representations, such as graphs, tables, journals, concept maps, and diagrams. 5.1.12.D.3: Demonstrate how to use scientific tools and instruments and knowledge of how to handle animals with respect for their safety and welfare. Physical Science: 5.2.12.D.2: Describe the potential commercial applications of exothermic and endothermic reactions. 5.2.12.D.3: Describe the products and potential applications of fission and fusion reactions. 5.2.12.D.4: Measure quantitatively the energy transferred between objects during a collision

	Technology: 8.1.12.A.1: Construct a spreadsheet, enter data, and use mathematical or logical functions to manipulate data, generate charts and graphs, and interpret the results. 8.1.12.C.1: Develop an innovative solution to a complex, local or global problem or issue in collaboration with peers and experts, and present ideas for feedback in an online community. 21st Century 9.1.12.A.1: Apply critical thinking and problem-solving strategies during structured learning experiences. 9.1.12.B.1: Present resources and data in a format that effectively communicates the meaning of the data and its implications for solving problems, using multiple perspectives. 9.1.12.C.4: Demonstrate leadership and collaborative skills when participating in online learning communities and structured learning experiences. 9.1.12.C.5: Assume a leadership position by guiding the thinking of peers in a direction that leads to successful completion of a challenging task or project.
Enduring Understandings:	Chemical or physical processes are driven by a decrease in enthalpy or an increase in entropy, or both. [EU 5.E] The equilibrium constant is related to temperature and the difference in Gibbs free energy between reactants and products. [EU 6.D] Chemical and physical transformations may be observed in several ways and typically involve a change in energy. [EU 3.C] Energy is neither created nor destroyed, but only transformed from one form to another. [EU 5.B] Breaking bonds requires energy, and making bonds releases energy. [EU 5.C] Electrostatic forces exist between molecules as well as between atoms or ions, and breaking the resultant intermolecular interactions requires energy. [EU 5.D]
Essential Questions:	When an auto mechanic informs you that your car battery is “dead,” what does that mean at the molecular level? If we say a reaction “takes place,” what factors make that happen? If you have metal fillings in your teeth, why does biting on aluminum foil cause so much pain?

	Why do saltwater fishermen place Zn plates on their boats' engines?
Critical Vocabulary	Spontaneous, thermodynamics, entropy, free energy, reversible process, irreversible process, second law of thermodynamics, third law of thermodynamics, Electrochemistry, Salt bridge, Porous disk, Galvanic cell, Anode, Cathode, Cell potential (Electromotive force), Volt, Voltmeter, Standard reduction potential, Faraday, Nerst equation,
All Students Will Know and Be Able To. . .	Some physical or chemical processes involve both a decrease in the internal energy of the components ($\Delta H° < 0$) under consideration and an increase in the entropy of those components ($\Delta S° > 0$). These processes are necessarily "thermodynamically favored" ($\Delta G° < 0$). [EK 5.E.2] If a chemical or physical process is not driven by both entropy and enthalpy changes, then the Gibbs free energy change can be used to determine whether the process is thermodynamically favored. [EK 5.E.3] External sources of energy can be used to drive change in cases where the Gibbs free energy change is positive. [EK 5.E.4] A thermodynamically favored process may not occur due to kinetic constraints (kinetic vs. thermodynamic control). [EK 5.E.5] Some physical or chemical processes involve both a decrease in the internal energy of the components ($\Delta H° < 0$) under consideration and an increase in the entropy of those components ($\Delta S° > 0$). These processes are necessarily "thermodynamically favored" ($\Delta G° < 0$). [EK 5.E.2] SKILLS In oxidation-reduction (redox) reactions, there is a net transfer of electrons. The species that loses electrons is oxidized, and the species that gains electrons is reduced. [EK 3.B.3] Electrochemistry shows the inter-conversion between chemical and electrical energy in galvanic and electrolytic cells. [EK 3.C.3] Entropy is a measure of the dispersal of matter and energy. [EK 5.E.1] Some physical or chemical processes involve both a decrease in the internal energy of the components ($\Delta H° < 0$) under consideration and an increase in the entropy of those components ($\Delta S° > 0$). These processes are necessarily

	"thermodynamically favored" ($\Delta G° < 0$). [EK 5.E.2] Predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both $\Delta H°$ and $\Delta S°$, and calculation or estimation of $\Delta G°$ when needed. [LO 5.13, SP 2.2, SP 2.3, SP 6.4, connects to 5.E.3] Determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy. [LO 5.14, SP 2.2, connects to 5.E.2] Explain how the application of external energy sources or the coupling of favorable with unfavorable reactions can be used to cause processes that are not thermodynamically favorable to become favorable. [LO 5.15, SP 6.2] Make quantitative predictions for systems involving coupled reactions that share a common intermediate, based on the equilibrium constant for the combined reaction. [LO 5.17, SP 6.4, connects to 6.A.2] Explain why a thermodynamically favored chemical reaction may not produce large amounts of product (based on consideration of both initial conditions and kinetic effects), or why a thermodynamically unflavored chemical reaction can produce large amounts of product for certain sets of initial conditions. [LO 5.18, SP 1.3, SP 7.2, connects to 6.D.1] Use conservation of energy to relate the magnitudes of the energy changes when two non-reacting substances are mixed or brought into contact with one another. [LO 5.5, SP 2.2, connects to 5.B.1, 5.B.2] Use representations and models to predict the sign and relative magnitude of the entropy change associated with chemical or physical processes. [LO 5.12, SP 1.4] Predict whether or not a physical or chemical process is thermodynamically favored by determination of (either quantitatively or qualitatively) the signs of both $\Delta H°$ and $\Delta S°$, and calculation or estimation of $\Delta G°$ when needed. [LO 5.13, SP 2.2, SP 2.3, SP 6.4, connects to 5.E.3] Determine whether a chemical or physical process is thermodynamically favorable by calculating the change in standard Gibbs free energy. [LO 5.14, SP 2.2, connects to 5.E.2] Analyze the enthalpic and entropic changes associated with the dissolution of a salt, using particulate level interactions and representations. [LO 6.24, SP 1.4, SP 7.1, connects to 5.E]

	Express the equilibrium constant in terms of $\Delta G°$ and RT, and use this relationship to estimate the magnitude of K and, consequently, the thermodynamic favorability of the process. [LO 6.25, SP 2.3] Identify redox reactions, and justify the identification in terms of electron transfer. [LO 3.8, SP 6.1] Make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws. [LO 3.12, SP 2.2, SP 2.3, SP 6.4] Design and/or interpret the results of an experiment involving a redox titration. [LO 3.9, SP 4.2, SP 5.1] Analyze data regarding galvanic or electrolytic cells to identify properties of the underlying redox reactions. [LO 3.13, SP 5.1] Make qualitative or quantitative predictions about galvanic or electrolytic reactions based on half-cell reactions and potentials and/or Faraday's laws. [LO 3.12, SP 2.2, SP 2.3, SP 6.4

EVIDENCE OF STUDENT LEARNING

Formative Performance Task:	Which Combination of Half-Cells Creates the Greatest Positive Voltage? (guided-inquiry lab): Working in groups you will design at least three galvanic cells from the half cells that can be created from the list of equipment that you were given. You will measure the voltage for each galvanic cell. In your individual lab reports you will analyze why the values of the standard potential do not match the predicted values. Working in groups you will predict whether the mixing of baking soda and vinegar is endothermic or exothermic, given that it is clearly thermodynamically favored. Each group will write their name and decision on a sheet f paper which I will collect and keep. I will then test your predictions by conducting the reaction and measuring the temperature with a thermometer. ju will include your predictions in your lab report and justify your answer using ΔG, ΔS etc. Coupled Reactions: You will calculate K values from the coupling of two reactions with common intermediates. You will then calculate $\Delta G°$ using $\Delta G° = RT\ln K$ to determine whether a reaction is thermodynamically favored or not favored.
Summative	In this 35-minute assessment, students answer 15 multiple-choice questions online and one free-response question.

Performance Task:	The multiple-choice section focuses on both conceptual and calculation questions regarding all topics covered in this unit, and at least five multiple-choice questions will focus on past units. The free-response question will focus on students' ability to draw a galvanic cell and label the parts of the cell and the flow of electrons. Students also calculate the standard potential. The second part of the problem uses Faraday's constant for a circuit and asks students to calculate the change in mass in the electrodes. The topic test consists of multiple-choice and free-response questions that require students to determine the sign of the enthalpy, entropy, and free energy changes for a described process. They indicate whether the process is thermodynamically favored, or if the favorability is temperature dependent. Students consider reactions that have large K values as well as negative values of ΔG, but they do not produce many products due to high activation energy. Students consider reactions that are coupled by a common intermediate and evaluate their favorability with and without the intermediate
Formal Evidence of Learning & Progress:	Exit Cards Presentations Written Responses Essays Quizzes Tests Research Projects Portfolios Journals Checklists Examinations of Student Work
Informal Evidence of Learning & Progress:	Exit Cards Presentations Reading Assessments (Oral, etc.) Pre-Assessments Portfolios Journals Checklists Peer Review Informal Observations/Dialogues Think A-louds

	Examinations of Student Work Self-Assessment /Reflection
LEARNING PLAN	
Required Activities:	Hook – Make a working galvanic cell Pre-assess – Q & A Focus Activity Lab experiments Problem sets Text book Handouts Online quizzes
Required Resources:	Read Text – Chemistry Zumdahl Zumdahl DeCoste 10th Edition View video clips Discussions Websites – Cengage Learning online
Suggested Activities:	Video Clips Additional problem sets
Suggested Resources:	Websites, books, video.
Strategies for Differentiation:	Readiness: small-group instruction, homework options, tiered assessments, compacting, multiple-entry points Interest: choices of books, homework options, explorations by interest and modes of expression (artistic, technological, written, oral, community service) Learning Style: organizational options, working choice options, flexible environment, Multiple Intelligences options