Unit 1: Atomic Structure and Properties

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 1**
Length: **6 weeks**
Status: **Published**

Standards and Phenomena

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
SCI.HS-PS1	Matter and Its Interactions
SCI.HS-PS1-8	Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
SCI.HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

Phenomena

1.1 Moles and Molar Mass

1.2 Mass Spectroscopy of elements

1.3 Elemental composition of pure substances

1.4 Composition of Mixtures

1.5 Atomic structure

1.6 Photoelectron Spectroscopy

1.7 Periodic Trends

1.8 Valence electrons and Ionic compounds

Science and Engineering Practices

1 Models and Representations
2 Question and Method
4 Model Analysis
5 Mathematical Routines

Planning and Carrying Out Investigations

Constructing Explanations and Designing Solutions

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Developing and Using Models

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Developing and Using Models

Planning and carrying out in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Disciplinary Core Ideas

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS4.A	Wave Properties
SCI.HS.PS4.B	Electromagnetic Radiation

Crosscutting Concepts

Energy and Matter

Stability and Change

Patterns

Systems and System Models

Cause and Effect

Transfer Goals

Transfer Goals

The atomic theory is the fundamental premise on which chemistry is based. Atoms are the building blocks of chemistry, while chemical properties are made from collections of atoms. Macroscopic systems involve such large numbers that moles are used as a unit. The periodic table provides information about predictable properties and periodicity as a function of atomic number. The electronic structure of an atom can be described by an electron configuration that provides a method of describing the distribution of electrons in an atom or ion. Understanding of atomic structure will be applied to models and representations of chemical

phenomena and explain changes and interactions of chemical substances.

Concepts

- Big Idea 1: Scale, proportion and quantity
- Big Idea 2: Structure and Properties

Essential Questions

- What is matter?
- What is the language of chemistry?
- How can we calculate quantities in a chemical reaction?
- How is emission of light related to the behavior of electrons?
- How are electrons arranged in atoms?
- What is the relationship between atomic structure and the periodic table?
- What are the periodic trends?

- What is a mole?
- What is the meaning of a chemical formula?
- How are atoms and molecules identified?
- What is the significance of the Periodic Table?

Understandings

SPQ-1 The mole allows for different units to be compared

SPQ-2 Chemical formulas identify substances by their unique combinations of atoms

SAP-1 Atoms and molecules can be identified by their electron distribution and energy

SAP-2 The periodic table shows patterns in electronic structure and trends in atomic properties

Critical Knowledge and Skills

Knowledge

SPQ-1.A.1 One cannot count particles directly, thus there must be a connection between the masses of the substances reacting and the actual number of particles undergoing chemical change.

SPQ-1.A.2 Avogadro's number (6.022×10^{23}) provides the connection between the number of moles in a pure sample of a substance and the number of constituent particles (or formula units) of that substance.

SPQ-1.A.3 Expressing the mass of an individual atom or molecule in atomic mass units (amu) is useful because the average mass of one particle in amu of a substance will always be numerically equal to the molar mass of that substance in grams. There is a quantitative connection between the mass of a substance and the number of particles that the substance contains.

Skills

5.B Identify an appropriate theory, definition, or mathematical relationship to solve a problem.

5.D Identify information presented graphically to solve a problem.

2.A Identify a testable scientific question based on an observation, data, or model.

5.A Identify quantities needed to solve a problem from given information.

1.A Describe the components of and quantitative information from models and representations that illustrate particulate-level properties only.

4.B Explain whether a model is consistent with chemical theories

4.A Explain chemical properties and phenomena (atoms, m/c) using given chemical theories, models, and representations

4.C Explain the connection between particulate-level and macroscopic properties of a substance using representations.

Assessment and Resources

School Summative Assessment Plan

- Ch 1 and 2 Test

- Ch 3 Test
- Ch 7 and 8 Test

- Ch 1 and 2 Test
- Ch 3 Test
- Ch 7 & 8 Test

School Formative Assessment Plan (Other Evidence)

- Assigned Homework
- Labs (See below)
- Personal Progress Check (MC and FR)

Primary Resources

Brown, LeMay, Bursten et al. Chemistry The Central Science. 13th edition. (Online)
Silberberg. Chemsitry. 3rd edition

Supplementary Resources

AP Classroom: Chemistry

- Lab: Analysis of Food Dyes in Beverages (AP Lab #1)
- AP Daily Videos
- Lab: Gravimetric Analysis of Calcium in Hard Water (AP Lab #3)
- Lab: Percentage of Copper in Brass (AP Lab #2)

Technology Integration and Differentiated Instruction

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Technology Integration

- **Spectrophotometer, colorimeter to analyze solutions**

- **AP Classroom**
  - Topic Questions
  - Topic Videos
  - Topic Quizzes
  - Personal Progress Checks

- **Google Products**
  - Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
  - GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

- **One to One Student's laptop**

- All students within the West Deptford School District are given a computer, allowing for 21st century learning to occur within every lesson/topic.

- **YouTube videos, tutorials, lab technique examples**

- **Additional Support Videos**

The videos below are just examples of videos that can be used to support each of the Lessons within this Topic.

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

Math

MA.S-IC	Making Inferences and Justifying Conclusions
MA.S-ID	Interpreting Categorical and Quantitative Data
MA.S-ID.A	Summarize, represent, and interpret data on a single count or measurement variable
MA.S-ID.B	Summarize, represent, and interpret data on two categorical and quantitative variables
MA.S-ID.C	Interpret linear models

ELA

LA.RH.11-12.4	Determine the meaning of words and phrases as they are used in a text, including analyzing how an author uses and refines the meaning of a key term over the course of a text (e.g., how Madison defines faction in Federalist No. 10).
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.
LA.WHST.11-12.1.A	Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
LA.WHST.11-12.1.E	Provide a concluding paragraph or section that supports the argument presented.
LA.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Learning Plan / Pacing Guide

Week 1:
Ch 1:Keys to Chemistry

Properties of matter
Unit conversions
Scientific measurement
Uncertainty and Sig Figs
Accuracy an precision

Week 2:
Ch 2: The Components of Matter

Elements, compounds, mixtures
Mass Laws
Atomic Theory
Introduction to the Periodic Table
Types of Bonding

Formulas and Nomenclature

Week 3:
Ch 3 Stoichiometry:

The Mole
Determining Formulas
Writing and Balancing Equations

Week 4:

Ch 3 Stoichiometry:
Stoichiometry
Solution Stoichiometry

Week 5:
Ch 7: Quantum Theory and Atomic Structure

The nature of light
Development of Modern Atomic Theory
Quantum numbers
Electron configurations

Week 6:
Ch 8: Electron Configuration and Chemical Periodicity
The development of the Periodic Table
Quantum mechanical model
Electron configurations
Complex patterns: Transition and inner transitions
Trends
Connection between atomic structure and chemical reactivity
Photoelectron Spectroscopy

Unit 2: Molecular and Ionic Compound Structure and Properties

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 1**
Length: **3 weeks**
Status: **Published**

Standards and Phenomena

Science Standards

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS4.A	Wave Properties
SCI.HS-PS4	Waves and Their Applications in Technologies for Information Transfer
SCI.HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
SCI.HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
SCI.HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SCI.HS-PS4-2	Evaluate questions about the advantages of using a digital transmission and storage of information.
SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
	Planning and Carrying Out Investigations
	Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
	Stability and Change
	Patterns
	Developing and Using Models
	Cause and Effect
	Constructing Explanations and Designing Solutions
	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems

and their components in the natural and designed worlds.

Phenomena

2.1 Types of chemical bonds

2.2 Intermolecular Forces and Potential Energy

2.3 Structure of Ionic Solids

2.4 Structure of metals and alloys

2.5 Lewis structures

2.6 Resonance and formal charge

2.7 VSPER and bond hybridization

Science and Engineering Practices

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Constructing Explanations and Designing Solutions

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Analyzing and Interpreting Data

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.

Mathematical and computational thinking at the 9–12 builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Using Mathematics and Computational Thinking

Constructing explanations and designing solutions in 9–12 builds on K–8 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Asking Questions and Defining Problems

Engaging in Argument from Evidence

Developing and Using Models

Asking questions and defining problems in grades 9–12 builds on K–8 experiences and

progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Planning and Carrying Out Investigations

Obtaining, Evaluating, and Communicating Information

Disciplinary Core Ideas

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS2.A	Forces and Motion
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS4.A	Wave Properties
SCI.HS.PS4.B	Electromagnetic Radiation

Crosscutting Concepts

Energy and Matter

Cause and Effect

Patterns

Stability and Change

Systems and System Models

Transfer Goals

Transfer Goals

Knowledge of atomic structure at the particulate level is connected to the macroscopic properties of the substance. Both chemical and physical properties of materials can be explained by the structure and arrangement of atoms, ions, or molecules and the forces between them. These forces, chemical bonds, are distinct from inter molecular attractions. Electronegativity can be used to make predictions about the type of bonding present between two atoms. Later, the students will use the periodic table and atomic properties to predict the type of bonding present.

Concepts

Big Idea 2: Structure and properties

Essential Questions

What is a bond?

What is VSEPR theory?

What are Lewis structures?

What is resonance?

What is Valence bond theory?

What are molecular geometries?

How do bonds affect the properties of substances?

What is Molecular orbital theory?

Understandings

SAP-3 Atoms or ions bond due to interactions between them, forming molecules

SAP-4 Molecular compounds are arranged based on Lewis structures and VSEPR theory

Critical Knowledge and Skills

Knowledge

SAP-3.A.1 Electronegatiity values for the representative elements increase going from left to right across the periodic table, and decrease going down a group. These trends can be understood qualitatively through electronic structure, the shell model and Coulomb's law.

SAP-3.A.2 Valence electrons shared between atoms of similar electronegativity constitute a nonpolar covalent bond.

SAP-3.A.3 Valence electrons shared between atoms of unequal electronegativity constitute a polar covalent bond.

a. the atom with the higher electronegativity will develop a partial negative charge relative to the other atom in the bond.
b. In single bonds, the greater differences in electronegativity lead to greater bond dipoles.
c. All polar bonds have some ionic character, and the difference between ionic and covalent is not distinct but rather a continuum.

SAP-3.A.4 The difference in electronegativity is not the only factor in determining if a bond should be designated as ionic or covalent. Generally, bonds between a metal and a nonmetal are ionic, and bonds between two nonmetals are covalent. Examination of the properties f a compound is the best way to characterize the type of bonding.

SAP-3.A.4 In a metallic solid, the valence electrons from the metal atoms are considered to be delocalized and not associated with any individual atom

SAP-3.B.1 A graph of potential energy vs distance between atoms is a useful representation for describing the interactions between atoms. They illustrate both the equilibrium bond length and the bond energy (the energy required to separate atoms)

SAP-3.B.2 In a covalent bond, the bond length is influenced by both the size of the atom's core and the bond order (single, double or triple). Bonds with higher bond orders are shorter and have larger bond energies.

SAP-3.B.3 Coulomb's law can be used to understand the strength and interactions between cations and anions.

a. because the interaction strength is proportional to the charge on each ion, larger charges lead to stronger interactions.
b. because the interaction strength increases as the distance between the centers of the ions decreases, smaller ions lead to stronger interactions.

SAP-3.C1 The cations and anion in a crystal are arranged in a systematic, periodic 3-D array that maximizes the attractive forces among cations and anions while minimizing the repulsive forces.

Skills

6.A Make a scientific claim

3.A Represent chemical phenomena using appropriate graphing techniques, including correct scale and units

4.C Explain the connection between particulate-level and macroscopic properties of a substance using representations.

3.B Represent chemical substances or phenomena with appropriate diagrams of models (ie. e- configs)

6.C Support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules

Assessment and Resources

Ch 9, 10 and Parts of 11 Test

School Formative Assessment Plan (Other Evidence)

Chapter Homework Sets
Unit Quizzes

Primary Resources

Brown, Lemay, Bursten, et al. Chemistry: The Central Science (online)
Silberberg, Chemistry

AP Classroom

School Summative Assessment Plan

Lab: Qualitative Analysis
Unit 2 Personal Progress Check

Supplementary Resources

AP Classroom
Demin, AP Chemistry Multiple Choice and Free Response

Pearson Education, AP Chemistry

Flinn AP Chemistry Labs

Bozeman Science: AP Chemistry (YouTube)

Technology Integration and Differentiated Instruction

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Technology Integration

- **Spectrophotometer, colorimeter to analyze solutions**

- **Vernier Graphical Analysis software and pH probes, gas pressure interfaces**

- **AP Classroom**
    - Topic Questions
    - Topic Videos
    - Topic Quizzes
    - Personal Progress Checks

- **Google Products**
    - Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
    - GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

- **One to One Student's laptop**
    - All students within the West Deptford School District are given a computer, allowing for 21st century learning to occur within every lesson/topic.

- **YouTube videos, tutorials, lab technique examples**

- **Additional Support Videos**

The videos below are just examples of videos that can be used to support each of the Lessons within this Topic.

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

ELA

LA.RH.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, qualitatively, as well as in words) in order to address a question or solve a problem.
LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.2	Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.
LA.WHST.11-12.1.A	Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
LA.WHST.11-12.1.E	Provide a concluding paragraph or section that supports the argument presented.
LA.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

LA.WHST.11-12.2.E	Provide a concluding paragraph or section that supports the argument presented.
LA.WHST.11-12.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Math

MA.S-IC	Making Inferences and Justifying Conclusions
MA.S-IC.A.2	Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation.
MA.S-IC.B	Make inferences and justify conclusions from sample surveys, experiments, and observational studies
MA.S-IC.B.5	Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.
MA.S-IC.B.6	Evaluate reports based on data.
MA.S-ID	Interpreting Categorical and Quantitative Data
MA.S-ID.A	Summarize, represent, and interpret data on a single count or measurement variable
MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
MA.S-ID.A.2	Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
MA.S-ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
MA.S-ID.B	Summarize, represent, and interpret data on two categorical and quantitative variables
MA.S-ID.B.5	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
MA.S-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
MA.S-ID.B.6a	Fit a function to the data (including with the use of technology); use functions fitted to data to solve problems in the context of the data.
MA.S-ID.B.6b	Informally assess the fit of a function by plotting and analyzing residuals, including with the use of technology.
MA.S-ID.B.6c	Fit a linear function for a scatter plot that suggests a linear association.
MA.S-ID.C	Interpret linear models
MA.S-ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
MA.S-ID.C.8	Compute (using technology) and interpret the correlation coefficient of a linear fit.

Learning Plan / Pacing Guide

Week 1:

Ch 9 Bonding
Types of bonds
Octet rule
Lewis structures
Metallic bonding
Ionic bonding

Week 2:

Ch 9 Bonding
Covalent bonding
Bond and molecular polarity
Resonance
Exceptions
Formal Charge

Week 3:

Ch 10 Molecular Geometries
Molecular geometries
Lab: Qualitative Analysis

Ch 11 Bonding Theories
Valence Bond Theory
Hybridization
Sigma and pi bonds
Molecular Orbital Theory

Unit 3: Intermolecular Forces and Properties

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 1**
Length: **3 weeks**
Status: **Published**

Standards and Phenomena

Science Standards

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
	Patterns
	Energy and Matter
	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
	Developing and Using Models

Phenomena

3.1 Intermolecular Forces

3.2 Properties of Solids

3.3 Solids, Liquids, Gases

3.4 Ideal Gas Law

3.5 Kinetic Molecular Theory

3.6 Deviation from Ideal Gas Law

3.7 Solutions and Mixtures

3.8 Representations of Solutions

3.9 Separation of solutions and mixtures chromatography

3.10 Solubility

3.11 Spectroscopy and the electromagnetic spectrum

3.12 Photoelectric effect

3.13 Beer-Lambert Law

Science and Engineering Practices

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Obtaining, Evaluating, and Communicating Information

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Analyzing and Interpreting Data

Mathematical and computational thinking at the 9–12 builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Using Mathematics and Computational Thinking

Constructing Explanations and Designing Solutions

Asking Questions and Defining Problems

Developing and Using Models

Asking questions and defining problems in grades 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Planning and Carrying Out Investigations

Constructing explanations and designing solutions in 9–12 builds on K–8 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Disciplinary Core Ideas

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS3.C	Relationship Between Energy and Forces
SCI.HS.PS4.A	Wave Properties
SCI.HS.PS4.B	Electromagnetic Radiation

Crosscutting Concepts

Cause and Effect

Scale, Proportion, and Quantity

Systems and System Models

Structure and Function

Patterns

Energy and Matter

Stability and Change

Concepts

Big Idea 1 Scale, Proportion and Quantity

Big Idea 2 Structure and Properties

Essential Questions

What are intermolecular forces?

How do interactions between particles influence mixtures?

How can you determine the concentration of a chemical species in a mixture?

What happens during a phase change?

What are solids?

What are the gas laws?

How are properties of gases described?

Understandings

SAP-5 Intermolecular forces (IMF) can explain the physical properties of a material.

SAP-6 Matter exists in three states: solid, liquid, and gas, and their differences are influenced by variances in spacing and motion of molecules.

SAP-7 Gas properties are explained macroscopically - using relationships among pressure, volume, temperature, moles, gas constant - and molecularly by the motion of the gas.

SPQ-3 Interactions between IMFs influence the solubility and separation of mixtures.

SAP-8 Spectroscopy can determine the structure and concentration in a mixture of chemical species.

Transfer Goals

Transfer Goals

Transformations of matter can be observed in ways that are categorized as either a chemical or physical change. The shapes of the particles involved and the space between them are key factors in determining the nature of physical changes. The properties of solids, liquids, and gases reflect their relative orderliness of the arrangement of particles in those states, their relative freedom of motion, and the nature and strength of interactions between them. There is a relationship between the macroscopic properties of solids, liquids and gases, as well as the structure of the constituent particles of those materials on the molecular and atomic scale. In subsequent units students will explore chemical transformations of matter.

Critical Knowledge and Skills

Knowledge

SAP-5.A Explain the relationship between chemical structures of molecules and the relative strength of the

IMFs when:

a. The molecules are of the same chemical species
b. The molecules are of two different chemical species

SAP-5.A.1 London Dispersion Forces (LD) are a result of the Coulombic interactions between temporary, fluctuating dipoles. LD are often the strongest net IMF between large molecules.

a. Dispersion forces increase with increasing contact area between molecules and with increasing polarizability of molecules.
b. The polarizability of a molecule increases with an increasing number of electrons in the molecule; and the size of the electron cloud. It is enhanced by the presence of pi bonding.
c. The term "London Dispersion Force" should not be used synonymously with the term "van der Waals forces".

SAP-5.A.2 The dipole moment of a polar molecule leads to additional interactions with other chemical species.

a. Dipole-induced dipole interactions are present between a polar and nonpolar molecule. These forces are always attractive. The strength of these forces increases with the magnitude of the dipole of the polar molecule and with the polarizability of the nonpolar molecule.
b. Dipole-dipole interactions are present between polar molecules. The interaction strength depends on the magnitudes of the dipoles and their relative orientation. Interactions between polar molecules are typically greater than those between nonpolar molecules of comparable size because these interactions act in addition to LD forces.
c. Ion-dipole forces of attraction are present between ions and polar molecules. These tend to be stronger than dipole-dipole forces.

SAP-5B Explain the relationship among macroscopic properties of a substance, the particulate-level structure of the substance, and the interactions between these particles.

SAP-6.A Represent the differences between solid, liquid, and gas phases using a particulate-level model.

SAP-7.A Explain the relationship between the macroscopic properties of a sample of gas or mixture of gases using the ideal gas law.

SAP-7.B Explain the relationship between the motion of particles and the macroscopic properties of gases with:

a. The kinetic molecular theory
b. A particle model
c. a graphical representation

SAP-7.C Explain the relationship among non-ideal behaviors of gases, interparticle forces, and/or volume

SPQ-3.A Calculate the number of solute particles, volume, or molarity of solutions.

SPQ-3.B Using particulate models for mixtures:

a. Represent interactions between components
b. Represent concentrations of componenets

Skills

4.D Explain the degree to which a model or representation describes the connection between particulate-model properties and macroscopic properties.

4.C Explain the connection between particulate-level and macroscopic properties of a substance using models and representations

3.C Represent visually the relationship between the structures and interactions across multiple levels or scales (particulate to macroscopic)

5.C Explain the relationship between variables within an equation when one variable changes

4.A Explain chemical properties or phenomena (of atoms or molecules) using given chemical theories, models and representations.

6.E Provide reasoning to justify a claim using connections between particulate and macroscopic scales or levels.

5.F Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (performing dimensional analysis and attending to significant digits)

2.C Identify the experimental procedures that are aligned to the question (which may include a sketch of a lab set up)

2.E Identify or describe potential sources of experimental error.

Assessment and Resources

School Formative Assessment Plan (Other Evidence)

Warm ups

Ch 12 HW Sets

Ch 5 HW Sets

Ch 1 HW sets

AP Lab #5 Separation of a dye mixture (chromatography)

AP Lab # 6 Qualitative Analysis

School Summative Assessment Plan

Unit 3 Test
Personal Progress Check 3 Multiple Choice
Personal Progress Check 3 Free Response

Primary Resources

Brown, Lemay, Bursten, et al. Chemistry: The Central Science (online)
Silberberg, Chemistry

AP Classroom

Supplementary Resources

Demin, AP Chemistry Multiple Choice and Free Response
Pearson Education, AP Chemistry

Flinn AP Chemistry Labs

Bozeman Science: AP Chemistry (YouTube)

Technology Integration and Differentiated Instruction

Technology Integration

- **Spectrophotometer, colorimeter to analyze solutions**

- **Vernier Graphical Analysis software and gas pressure interfaces**

- **AP Classroom**

- Topic Questions
- Topic Videos
- Topic Quizzes
- Personal Progress Checks

● **Google Products**

- Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
- GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

● **One to One Student's laptop**

- All students within the West Deptford School District are given a computer, allowing for 21st century learning to occur within every lesson/topic.

● **YouTube videos, tutorials, lab technique examples**

● **Additional Support Videos**

The videos below are just examples of videos that can be used to support each of the Lessons within this Topic.

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

Math

MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
MA.S-ID.A.2	Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.

MA.S-ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
MA.S-ID.B.5	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
MA.S-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
MA.S-ID.B.6a	Fit a function to the data (including with the use of technology); use functions fitted to data to solve problems in the context of the data.
MA.S-ID.B.6b	Informally assess the fit of a function by plotting and analyzing residuals, including with the use of technology.
MA.S-ID.B.6c	Fit a linear function for a scatter plot that suggests a linear association.
MA.S-ID.C	Interpret linear models
MA.S-ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
MA.S-ID.C.8	Compute (using technology) and interpret the correlation coefficient of a linear fit.

ELA

LA.RST.11-12	Reading Science and Technical Subjects
LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.6	Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.
LA.WHST.11-12.1	Write arguments focused on discipline-specific content.
LA.WHST.11-12.1.E	Provide a concluding paragraph or section that supports the argument presented.
LA.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.11-12.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Learning Plan / Pacing Guide

Week 1:

Ch 12: Intermolecular Forces (IMF): Liquids, Solids, Phase Changes
States of matter
London dispersion
Dipole-dipole
Hydrogen bonding
Properties of liquids
Phase changes
Vapor pressure
Phase diagrams
Structures of solids

Week 2:

Ch 5: Gases and the Kinetic Molecular Theory (KMT)

Gas pressure
The Gas Laws
Gas Stoichiometry
KMT
Ideal and non-ideal gases

Week 3:

Ch 13: The Properties of Mixtures: Solutions ans Colloids
Separation of Solutions and Mixtures Chromatography
Solubility
Spectroscopy and the Electromagnetic Spectrum
Photoelectric Effect
Beer-Lambert Law

Unit 4: Chemical Reactions

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 2**
Length: **2 weeks**
Status: **Published**

Standards and Phenomena

SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
SCI.HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

Science Standards

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
SCI.HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
SCI.HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Patterns

Phenomena

4.1 Introduction to reactions

4.2 Net ionic equations

4.3 Representations of reactions

4.4 Physical and chemical changes

4.5 Stoichiometry

4.6 Introduction to titration

4.7 Types of chemical equations

4.8 Introduction to acid-base reactions

4.9 Oxidation-reduction (redox) reactions

Science and Engineering Practices

Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.

Constructing Explanations and Designing Solutions

Analyzing and Interpreting Data

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Mathematical and computational thinking at the 9–12 builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Using Mathematics and Computational Thinking

Constructing explanations and designing solutions in 9–12 builds on K–8 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show how relationships among variables between systems and their components in the natural and designed worlds.

Asking Questions and Defining Problems

Developing and Using Models

Asking questions and defining problems in grades 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Planning and Carrying Out Investigations

Obtaining, Evaluating, and Communicating Information

Disciplinary Core Ideas

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.A	Forces and Motion
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS3.D	Energy in Chemical Processes and Everyday Life
SCI.HS.ESS2.C	The Roles of Water in Earth's Surface Processes
SCI.HS.ESS2.D	Weather and Climate

Crosscutting Concepts

Energy and Matter

Cause and Effect

Scale, Proportion, and Quantity

Structure and Function

Stability and Change

Patterns

Systems and System Models

Transfer Goals

Transfer Goals

Chemical transformations of matter builds on the physical transformations studies in Unit 3. Chemical changes involve the making and braking of bonds. Many properties of a chemical system can be understood using the concepts of varying strengths of chemical bonds and weaker intermolecular forces. When chemical changes occur, the new substances formed have properties that are distinguishable from the initial substance or substances. Chemical reactions are the primary means by which chemical transformations occur. Chemical equations are a representation of the rearrangement of atoms that occur during a chemical reaction. Later, student will explore the rates at which chemical reactions occur.

Concepts

Bid idea 1 Scale, proportion, and quantity

Big idea 3 Transformations

Essential Questions

- how can we represent what happens during a chemical reaction?
- how can we predict products of a reaction?
- how can we determine amounts of reactants needed or products formed?
- what is a redox reaction?

Understandings

TRA-1 A substance that changes its properties, or that changes into a different substance, can be represented by chemical equations.

SPQ-4 When a substance changes into a new substance, or when its properties change, no mass is lost or gained.

TRA-2 A substance can change into another substance through different processes, and the change itself can be classified by the sort of process that produced it.

Critical Knowledge and Skills

Knowledge

TRA-1.A Identify evidence of chemical and physical changes in matter

TRA-1.B Represent changes in matter with a balanced chemical equation:

a. for physical changes
b. for given information about the identity of the reactants and/or products
c. for ions in a given chemical reaction

TRA-1.C Represent a given chemical reaction or physical process with a consistent particulate model

TRA-1.D Explain the relationship between macroscopic characteristics and bond interactions for:

a. chemical processes

b. physical processes

SPQ-4.A Explain the changes in the amounts of reactants and products based on the balanced chemical equation for a chemical process

SPQ-4B Identify the equivalence point in a titration based on the amounts of titrant and analyte, assuming the titration goes to completion

TRA-2.A Identify a reaction as acid-base, redox, or precipitation

TRA-2.B Identify species as Brønsted-Lowry acids, bases or conjugate acid-base pairs, based on proton transfer involving those species

TRA-2.C Represent a balanced redox reaction using half-reactions

Skills

2.B Formulate a hypothesis or predict the results of an experiment

5.E Determine a balanced chemical equation for a given chemical phenomena

3.B Represent chemical substances or phenomena with appropriate diagrams or models (e- configs)

6.B Support a claim with evidence

5.C Explain the relationship between variables within an equation when one variable changes

3.A Represent chemical phenomena using appropriate graphing techniques, including correct scale and units

1.B Describe the components of and quantitative information from models and representations that illustrate both particulate-level and macrpscopic-level properties

Assessment and Resources

School Formative Assessment Plan (Other Evidence)

Ch 4 HW Sets

AP Classroom Videos

AP Classroom Quizzes

AP Lab # 4: How much acid is in fruit drinks?

AP Lab # 8: Percentage of Hydrogen Peroxide (redox titration)

School Summative Assessment Plan

Ch 4 Test

Primary Resources

Brown, Lemay, Bursten, et al. Chemistry: The Central Science (online)
Silberberg, Chemistry

AP Classroom

Supplementary Resources

Demin, AP Chemistry Multiple Choice and Free Response
Pearson Education, AP Chemistry

Flinn AP Chemistry Labs

Bozeman Science: AP Chemistry (YouTube)

Technology Integration and Differentiated Instruction

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

- ❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to

explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Technology Integration

- **Spectrophotometer, colorimeter to analyze solutions**

- **Vernier Graphical Analysis software and pH probes, gas pressure interfaces**

- **AP Classroom**
    - Topic Questions
    - Topic Videos
    - Topic Quizzes

- Personal Progress Checks

- **Google Products**
    - Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
    - GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

- **One to One Student's laptop**
    - All students within the West Deptford School District are given a computer, allowing for 21st century learning to occur within every lesson/topic.

- **YouTube videos, tutorials, lab technique examples**

- **Additional Support Videos**

The videos below are just examples of videos that can be used to support each of the Lessons within this Topic.

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

Math

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).

ELA

LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

Learning Plan / Pacing Guide

Week 1:

Aqueous solutions
Electrolytes
Writing equations
Precipitation Reactions
Acid-Base Reactions
Stoichiometry Review
Titrations

Week 2:

Redox Reactions
Determining oxidation numbers
Balancing Redox

Unit 5: Kinetics

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 2**
Length: **3 weeks**
Status: **Published**

Standards and Phenomena

Science Standards

SCI.HS.PS1.B	Chemical Reactions
SCI.HS-ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
SCI.HS-ESS3-4	Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
SCI.HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
	Mathematical and computational thinking at the 9–12 builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
	Cause and Effect
	Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

Phenomena

5.1 Reaction Rates

5.2 Intro to Rate law

5.3 Concentration changes over time

5.4 Elementary reactions

5.5 Collision model

5.6 Reaction energy profile

5.7 Intro to reaction mechanisms

5.8 Reaction mechanism and rate law

5.9 Steady-state approximation

5.10 Multi-step reaction energy profile

5.11 Catalysis

Science and Engineering Practices

SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
SCI.HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
	Constructing Explanations and Designing Solutions
	Planning and Carrying Out Investigations
	Developing and Using Models
	Using Mathematics and Computational Thinking
	Analyzing and Interpreting Data
	Obtaining, Evaluating, and Communicating Information
	Engaging in Argument from Evidence

Disciplinary Core Ideas

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS3.A	Definitions of Energy

SCI.HS.PS3.B	Conservation of Energy and Energy Transfer
SCI.HS.PS3.C	Relationship Between Energy and Forces
SCI.HS.PS3.D	Energy in Chemical Processes and Everyday Life
SCI.HS.ETS1.C	Optimizing the Design Solution
SCI.HS-PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SCI.HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Crosscutting Concepts

SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
SCI.HS-PS3-5	Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
	Patterns
	Structure and Function
	Systems and System Models
	Stability and Change
	Cause and Effect
	Scale, Proportion, and Quantity
	Energy and Matter

Transfer Goals

Transfer Goals

Building off of Unit 4 and chemical changes, Unit 5 develops the understanding of the rates at which chemical reactions occur and the factors that influence the rates. Those factors include the concentrations, temperature, catalysts and other environmental factors. Chemical changes are represented by chemical reactions, and the rates of chemical reactions are determined by the details of the molecular collisions. Rates of change in chemical reactions are observable and measurable. When measuring rates of change, students are measuring the concentration of reactant or product species as a function of time. These processes may be observed in a variety of ways and often involve changes in energy as well. In following the units students will describe the roles of energy in changes in matter.

Concepts

Big Idea 3 Transformations

Bid Idea 4 Energy

Essential Questions

1. How can we determine the rate of a reaction?
2. How can we determine the reaction order and rate constant?
3. What is a first order integrated reaction?
4. What is a second order integrated reaction
5. What is collision theory?
6. How can we determine concentrations during a reaction?
7. What is a reaction mechanism?
8. What is a catalyst?

Understandings

TRA-3 Some reactions happen quickly, while others happen more slowly and depend on reactant concentration and temperature.

TRA-4 There is a relationship between the speed of a reaction and the collision frequency of particle collisions.

TRA-5 Many chemical reactions occur through a series of elementary reactions. These elementary reactions when combined form a chemical equation.

ENE-1 The speed at which a reaction occurs can be influenced bu a catalyst.

Critical Knowledge and Skills

Knowledge

TRA-3.A Explain the relationship between the rare of a chemical reaction and experimental parameters.

TRA-3.B Represent experimental data with a consistent rate law expression.

TRA-3.C Identify the rate law expression of a chemical reaction using data that show how the concentrations of reaction species change over time.

TRA-4.A Represent an elementary reaction as a rate law expression using stoichiometry.

TRA-4.B Explain the relationship between the rate law of an elementary reaction and the frequency, energy, and orientation of molecular collisions.

TRA-4.C Represent the activation energy and overall energy change in an elementary reaction using a reaction energy profile.

TRA-5.A Identify the components of a reaction mechanism

TRA-5.B Identify the rate law for a reaction from a mechanism in which the first step is the rate determining step.

TRA-5.C Identify the rate law for a reaction from a mechanism in which the first step is not the rate determining step.

TRA-5.D Represent the activation energy and overall energy change in a multi-step reaction with a reaction energy profile

ENE-1.A Explain the relationship between the effect of a catalyst on a reaction and changes in the reaction mechanism

Skills

6.E Provide reasoning to justify a claim using particulate and macroscopic scales or levels.

5.C Explain the relationship between variables within an equation when one variable changes.

5.B Identify an appropriate theory, definition or mathematical relationship to solve a problem.

5.E Determine a balanced chemical equation for a given chemical phenomena

3.B Represent chemical substances or phenomena with appropriate diagrams or models (e.g., e-configurations)

1.B Describe the components of and quantitative information from models and representations that illustrate both particulate-level and macroscopic-level properties

Assessment and Resources

School Formative Assessment Plan (Other Evidence)

Ch 16 HW Sets

AP Classroom Videos

AP Classroom Quizes

AP Lab #10: How long will that marble statue last?

AP Lab #11: What is the rate laaw of crystal violet fading?

School Summative Assessment Plan

Ch 16 Test

Primary Resources

Brown, Lemay, Bursten, et al. Chemistry: The Central Science (online)
Silberberg, Chemistry

AP Classroom

Supplementary Resources

Demin, AP Chemistry Multiple Choice and Free Response
Pearson Education, AP Chemistry

Flinn AP Chemistry Labs

Bozeman Science: AP Chemistry (YouTube)

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

Math

MA.S-CP.A.4	Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities.
MA.S-IC	Making Inferences and Justifying Conclusions
MA.S-IC.A.2	Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation.
MA.S-ID	Interpreting Categorical and Quantitative Data
MA.S-ID.A	Summarize, represent, and interpret data on a single count or measurement variable
MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).

MA.S-ID.A.2	Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
MA.S-ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
MA.S-ID.B	Summarize, represent, and interpret data on two categorical and quantitative variables
MA.S-ID.B.5	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
MA.S-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
MA.S-ID.B.6a	Fit a function to the data (including with the use of technology); use functions fitted to data to solve problems in the context of the data.
MA.S-ID.B.6b	Informally assess the fit of a function by plotting and analyzing residuals, including with the use of technology.
MA.S-ID.B.6c	Fit a linear function for a scatter plot that suggests a linear association.
MA.S-ID.C	Interpret linear models
MA.S-ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
MA.S-ID.C.8	Compute (using technology) and interpret the correlation coefficient of a linear fit.
MA.A-REI.B.4	Solve quadratic equations in one variable.
MA.A-REI.B.4a	Use the method of completing the square to transform any quadratic equation in x into an equation of the form $(x - p)^2 = q$ that has the same solutions. Derive the quadratic formula from this form.
MA.A-REI.B.4b	Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers a and b.
MA.A-REI.C.7	Solve a simple system consisting of a linear equation and a quadratic equation in two variables algebraically and graphically.

ELA

LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR

	text complexity band independently and proficiently.
LA.WHST.11-12.1.A	Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
LA.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.11-12.2.E	Provide a concluding paragraph or section that supports the argument presented.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Technology Integration and Differentiated Instruction

Technology Integration

●AP Classroom

Topic videos
Concept Quizzes
Personal Progress Checks

●Google Products

- Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
- GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

● One to One Student's laptop

- All students within the West Deptford School District are given a computer, allowing for 21st century learning to occur within every lesson/topic.

● Additional Support Videos

The videos below are just examples of videos that can be used to support each of the Lessons within this Topic.

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Learning Plan / Pacing Guide

Week 1:

Reaction rates

Intro to rate laws

Concentration changes over time

Week 2:

Elementary reactions

Collision theory

Reaction energy profiles

Intro to mechanisms

Week 3:

Mechanisms and rate laws

Steady-state approximations

Multi-step reaction energy profiles

Catalysts

Unit 6: Thermodynamics

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 3**
Length: **2 weeks**
Status: **Published**

Standards and Phenomena

Science Standards

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS-ESS3-5	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
SCI.HS-ETS1-2	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
SCI.HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. Asking questions and defining problems in grades 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. Constructing explanations and designing solutions in 9–12 builds on K–8 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. Planning and carrying out investigations in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science. Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. Mathematical and computational thinking at the 9–12 builds on K–8 and progresses to

using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

Phenomena

6.1 Endothermic and exothermic processes

6.2 Energy diagrams

6.3 Heat transfer and thermal equilibrium

6.4 Heat capacity and calorimetry

6.5 Energy of phase changes

6.6 Intro to enthalpy of reaction

6.7 Bond enthalpies

6.8 Enthalpy of formation

6.9 Hess' Law

Science and Engineering Practices

SCI.HS-ESS3-2	Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
SCI.HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change).
SCI.HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
SCI.HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
SCI.HS-PS1-1	Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
SCI.HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
SCI.HS-PS1-8	Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
	Constructing Explanations and Designing Solutions
	Planning and Carrying Out Investigations
	Using Mathematics and Computational Thinking
	Planning and Carrying Out Investigations
	Engaging in Argument from Evidence
	Constructing Explanations and Designing Solutions
	Using Mathematics and Computational Thinking
	Developing and Using Models
	Obtaining, Evaluating, and Communicating Information
	Asking Questions and Defining Problems

Disciplinary Core Ideas

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS3.A	Definitions of Energy
SCI.HS.PS3.B	Conservation of Energy and Energy Transfer
SCI.HS.PS3.C	Relationship Between Energy and Forces
SCI.HS.PS3.D	Energy in Chemical Processes and Everyday Life
SCI.HS.PS3.D	Energy in Chemical Processes
SCI.HS.ESS3.D	Global Climate Change
SCI.HS.ETS1.A	Delimiting Engineering Problems
SCI.HS.ETS1.B	Developing Possible Solutions
SCI.HS.ETS1.C	Optimizing the Design Solution
SCI.HS-ETS1-3	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
SCI.HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
SCI.HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.

Crosscutting Concepts

SCI.HS-ESS3-6	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change).
SCI.HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
SCI.HS-PS3-1	Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
SCI.HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
SCI.HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
SCI.HS-PS2	Motion and Stability: Forces and Interactions
SCI.HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
SCI.HS-PS3-4	Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
	Structure and Function
	Systems and System Models
	Patterns
	Scale, Proportion, and Quantity
	Stability and Change
	Cause and Effect
	Energy and Matter

Transfer Goals

Transfer Goals

The roles of thermodynamics describe the essential role of energy and explain and predict the direction of changes in matter. The availability or disposition of energy plays a role in virtually all observed chemical processes. Thermodynamics provides tools for understanding this key role, particularly the conservation of energy, including energy transfer in the form of heat and work. Chemical bonding is central to chemistry. A key concept to know is that the breaking of a chemical bond inherently requires an energy input, and because bond formation is the reverse process, it will release energy. In the following units, the application of thermodynamics will determine the favorability of a reaction occurring.

Concepts

Big Idea 4: Energy

Essential Questions

1. What is energy?
2. What is heat?
3. How do we use Hess' Law?
4. How can we determine the heat of reaction?
5. What is calorimetry?
6. What is thermochemistry?

Understandings

ENE-2 Changes in a substance's properties or change into a different substance requires an exchange of energy.

ENE-3 The energy exchanged in a chemical transformation is required to break and form bonds.

Critical Knowledge and Skills

Knowledge

ENE-2.A Explain the relationship between experimental observations and energy changes associated with a chemical or physical transformation

ENE-2.B Represent a chemical or physical transformation with an energy diagram

ENE-2.C Explain the relationship between the transfer of thermal energy and molecular collisions

ENE-2.D Calculate the heat, q , absorbed or released by a system undergoing heating/cooling based on the amount of the substance, the heat capacity, and the change in temperature

ENE-2.E Explain changes in the heat, q , absorbed or released by a system undergoing a phase transition based on the amount of the substance in moles and molar enthalpy of the phase transition

ENE-2.F Calculate the heat, q , absorbed or released by a system undergoing a chemical reaction in relationship to the amount of the reacting substance in moles and molar enthalpy of the phase transition

ENE-3.A Calculate the enthalpy change of a reaction based on the average bond energies of bonds broken and formed in the reaction

ENE-3.B Calculate the enthalpy change for a chemical or physical prcess based on the standard enthalpies of formation

ENE-3.C Represent a chemical or physical process as a sequence of steps

ENE3.D Explain the relationship between the enthalpy of a chemical or physical process and the sum of the enthalpies of the individual steps

Skills

6.D Provide reasoning to justify a claim using chemical principles or laws, or using mathematical justification

3.A Represent chemical phenomena using appropriate graphing techniques, including correct scale and units

6.E Provide reasoning to justify a claim using connections between particulate and macroscopic scales or levels

2.D Male observations or collect data from representations of laboratory setups or results, while attending to precision where appropriate

1.B Describe the components of and quantitative information from models and representations that illustrate

both particulate-level and macroscopic-level properties

4.C Explain the connection between particulate-level and macroscopic-level properties of a substance using models and representations

5.F Calculate, estimate, or predict and unknown quantity from known quantities by selecting and following a logical computational pathway amd attending to precision (eg. performing dimensional analysis and attending to significant figures)

5.A Identify quantities needed to solve a problem from given information (eg. text, mathematical expressions, graphs, or tables)

Assessment and Resources

School Formative Assessment Plan (Other Evidence)

Ch 6 HW Sets

AP Classroom Videos

AP Classroom Quizzes

AP Lab #12: Hand warmer design

School Summative Assessment Plan

Ch 6 Test

Primary Resources

Brown, Lemay, Bursten, et al. Chemistry: The Central Science (online)
Silberberg, Chemistry

AP Classroom

Supplementary Resources

Demin, AP Chemistry Multiple Choice and Free Response
Pearson Education, AP Chemistry

Flinn AP Chemistry Labs

Bozeman Science: AP Chemistry (YouTube)

Technology Integration and Differentiated Instruction

Technology Integration

- **Vernier Graphical Analysis software and temperature probes**

- **AP Classroom**
    - Topic Questions
    - Topic Videos
    - Topic Quizzes
    - Personal Progress Checks

- **Google Products**
    - Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
    - GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

- **One to One Student's laptop**
    - All students within the West Deptford School District are given a computer, allowing for 21st century learning to occur within every lesson/topic.

- **YouTube videos, tutorials, lab technique examples**

- **Additional Support Videos**

The videos below are just examples of videos that can be used to support each of the Lessons within this

Topic.

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

Math

MA.N-Q.A	Reason quantitatively and use units to solve problems.
MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
MA.S-ID.A	Summarize, represent, and interpret data on a single count or measurement variable
MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
MA.S-ID.A.2	Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
MA.S-ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
MA.S-ID.C	Interpret linear models
MA.S-ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

ELA

LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.

LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.
LA.WHST.11-12.1.A	Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
LA.WHST.11-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
LA.WHST.11-12.7	Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Learning Plan / Pacing Guide

Week 1:

Endothermic and exothermic processes

Energy diagrams

Heat transfer and thermal equilibrium

Week 2:

Heat capacity and calorimetry

Energy of phase changes

Intro to enthalpy of reaction

Bond enthalpies

Enthalpy of formation

Hess' Law

Unit 7: Equilibrium

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 3**
Length: **3 weeks**
Status: **Published**

Standards and Phenomena

Science Standards

SCI.HS.PS1.B	Chemical Reactions
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
SCI.HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
	Patterns
	Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Phenomena

7.1 Introduction to equilibrium

7.2 Direction of Reversible Reactions

7.3 Reaction Quotient and Equilibrium Constant

7.4 Calculating equilibrium constants

7.5 Magnitude of the equilibrium constant

7.6 Properties of the equilibrium constant

7.7 Calculating equilibrium concentrations

7.8 Representations of equilibrium

7.9 Intro to Le Chatelier's principle

7.10 Reaction quotients and Le Chatelier's principle

7.11 Intro to solubility equilibria

7.12 Common ion effect

7.13 pH and solubility

7.14 Free energy of dissolution

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information

Analyzing and Interpreting Data

Developing and Using Models

Constructing Explanations and Designing Solutions

Using Mathematics and Computational Thinking

Asking Questions and Defining Problems

Planning and Carrying Out Investigations

Engaging in Argument from Evidence

Disciplinary Core Ideas

SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.ETS1.B	Developing Possible Solutions
SCI.HS.ETS1.C	Optimizing the Design Solution

Crosscutting Concepts

Cause and Effect

Patterns

Stability and Change

Transfer Goals

Transfer Goals

Chemical equilibrium is a dynamic state in which opposing processes occur at the same rate. In this Unit,

students will learn that any bond or intermolecular attraction that can be formed can be broken. These two processes are in dynamic competition, sensitive to initial conditions and external perturbations. A change in conditions, such as the addition of a chemical species, change in temperature, or change in volume, can cause the rate of the forward and reverse reactions to fall out of balance. Le Chatelier's principle provides a means ro reason quantitatively about the direction of the shift in an equilibrium system resulting from various possible stresses. The expression for the equilibrium constant, K, is a mathematical expression that describes the equilibrium state associated with a chemical change. An analogous expression for the reaction quotient, Q, describes a chemical reaction at any point, enabling a comparison to the equilibrium state. Subsequent units will explore equilibrium constants that arise from acid-base chemistry.

Concepts

Big Idea 1 Scale, proportion and quantity

Big Idea 3 Transformation

Essential Questions

1. What is equilibrium?
2. How can we calculate initial, changes, and equilibrium quantities in reactants and products?
3. What can cause a stress on a system at equilibrium?
4. How can we predict how a system at equilibrium will respond to a stress?
5. What is the common ion effect?

Understandings

TRA-6 Some reactions can occur in both forward and reverse directions, sometimes proceeding in each direction simultaneously.

TRA-7 A system at equilibrium depends on the relationships between concentrations, partial pressures of chemical species, and equilibrium constant, K.

TRA-8 Systems at equilibrium respond to external stresses to offset the effect of the stress.

SPQ-5 The dissolution of a salt is a reversible process that can be influenced by environmental factors such as pH or other dissolved ions.

Critical Knowledge and Skills

Knowledge

TRA-6.A Explain the relationship between the occurrence of a reversible chemical or physical process, and the establishment of equilibrium, to experimental observations.

TRA-6.B Explain the relationship between the direction in which a reversible reaction proceeds and the relative rates of the forward and reverse reactions.

TRA-7.A Represent the reaction quotient, Q_c or Q_p, for a reversible reaction, and the corresponding equilibrium expressions $K_c = Q_c$ or $K_p = Q_p$.

TRA-7.B Calculate K_c or K_p based on experimental observations of concentrations or pressures at equilibrium.

TRA-7.C Explain the relationship between very large or very small values of K and the relative concentrations of chemical species at equilibrium

TRA-7.D Represent a multi-step process with an overall equilibrium expression, using the constituent K expressions for each individual reaction.

TRA-7.E Identify the concentration or partial pressures of chemical species at equilibrium based on the initial conditions and the equilibrium constant.

TRA-7.F Represent a system undergoing a reversible reaction with a particulate model.

TRA-8.A Identify the response of a system at equilibrium to an external stress, using Le Châtelier's principle.

TRA-8.B Explain the relationships between K, Q, and the direction in which a reversible reaction will proceed to reach equilibrium.

SPQ-5.A Calculate the solubility of a salt based on the value of K_{sp} for the salt.

SPQ-5.B Identify the solubility of a salt, and/or the value of K_{sp} for the salt, based n the concentration of a common ion already present in solution.

SPQ-5.C Identify the qualitative effect of changes in pH on the solubility of a salt.

SPQ-5.D Explain the relationship between the solubility of a salt and changes in the enthalpy and entropy that occur in the dissolution process.

Skills

6.D Provide reasoning to justify a claim using chemical principles or laws, or using mathematical justification.

4.D Explain the degree to which a model or representation describes the connection between particulate-level

properties and macroscopic properties.

3.A Represent chemical phenomena using appropriate graphing techniques, including correct scale and units.

5.C Explain the relationship between variables within an equation when one variable changes

5.A Identify quantities needed to solve a problem from given information (eg. text, mathematical expressions, graphs or tables)

3.C Represent visually the relationship between the structures and interactions across multiple levels or scales (eg. particulate to macroscopic)

6. F Explain the connection between experimental results and chemical concepts, processes or theories.

5.F Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (eg. perfomring dimensional analysis and attending to significant figures)

Assessment and Resources

School Formative Assessment Plan (Other Evidence)

Ch 17 HW Sets

AP Classroom videos

AP Classroom Quizzes

AP Lab #13: Applications of Le Chatelier's principle

School Summative Assessment Plan

Ch 17 Test

Primary Resources

Brown, Lemay, Bursten, et al. Chemistry: The Central Science (online)
Silberberg, Chemistry

AP Classroom

Supplementary Resources

Demin, AP Chemistry Multiple Choice and Free Response
Pearson Education, AP Chemistry

Flinn AP Chemistry Labs

Bozeman Science: AP Chemistry (YouTube)

Technology Integration and Differentiated Instruction

Technology Integration

- **Spectrophotometer, colorimeter to analyze solutions**

- **Vernier Graphical Analysis software and pH probes**

- **AP Classroom**
    - Topic Questions
    - Topic Videos
    - Topic Quizzes
    - Personal Progress Checks

- **Google Products**
    - Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
    - GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

- **One to One Student's laptop**
    - All students within the West Deptford School District are given a computer, allowing for 21st

century learning to occur within every lesson/topic.

- **YouTube videos, tutorials, lab technique examples**

- **Additional Support Videos**

The videos below are just examples of videos that can be used to support each of the Lessons within this Topic.

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so

modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

Math

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
MA.N-RN.A.1	Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents.
MA.N-RN.A.2	Rewrite expressions involving radicals and rational exponents using the properties of exponents.
MA.S-ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
MA.S-ID.B.5	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
MA.S-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
MA.S-ID.B.6a	Fit a function to the data (including with the use of technology); use functions fitted to data to solve problems in the context of the data.

MA.S-ID.B.6b	Informally assess the fit of a function by plotting and analyzing residuals, including with the use of technology.
MA.S-ID.B.6c	Fit a linear function for a scatter plot that suggests a linear association.
MA.S-ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
MA.S-ID.C.8	Compute (using technology) and interpret the correlation coefficient of a linear fit.
MA.A-CED.A.1	Create equations and inequalities in one variable and use them to solve problems.
MA.A-CED.A.2	Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.
MA.A-CED.A.3	Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context.
MA.A-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.
MA.A-SSE.A.1b	Interpret complicated expressions by viewing one or more of their parts as a single entity.
MA.A-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
MA.A-SSE.B.3a	Factor a quadratic expression to reveal the zeros of the function it defines.
MA.A-SSE.B.3b	Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.

ELA

LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

Learning Plan / Pacing Guide

Week 1:

Intro to equilibrium

Direction of reversible reactions

Reaction quotient and equilibrium constant

Calculating equilibrium constants

Magnitude of the equilibrium constant

Week 2:

Properties of the equilibrium constant

Calculating equilibrium concentrations

Representations of equilibrium

Intro to LeChatelier's principle

Week 3:

Reaction quotients and LeChatelier's principle

Intro to solubility equilibria

Common ion effect

pH and solubility

Free energy of dissolution

Unit 8: Acid Base Equilibrium

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 3**
Length: **3 weeks**
Status: **Published**

Standards and Phenomena

Science Standards

SCI.HS.PS1.B	Chemical Reactions
SCI.HS-PS1-6	Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.
SCI.HS-PS1-5	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
	Constructing Explanations and Designing Solutions
	Patterns

Phenomena

8.1 Introduction to acids and bases

8.2 pH and pOH of strong acids and bases

8.3 Weak acid and base equilibrium

8.4 Acid-Base Reactions and buffers

8.5 Acid-Bases Titrations

8.6 Molecular structures of acids and bases

8.7 pH and pKa

8.8 Properties of buffers

8.9 Henderson-Hasselbalch Equation

8.10 Buffer Capacity

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information

Developing and Using Models

Analyzing and Interpreting Data

Engaging in Argument from Evidence

Using Mathematics and Computational Thinking

Constructing Explanations and Designing Solutions

Engaging in Argument from Evidence

Obtaining, Evaluating, and Communicating Information

Planning and Carrying Out Investigations

Constructing Explanations and Designing Solutions

Asking Questions and Defining Problems

Disciplinary Core Ideas

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.ETS1.B	Developing Possible Solutions
SCI.HS.ETS1.C	Optimizing the Design Solution

Crosscutting Concepts

Cause and Effect

Systems and System Models

Structure and Function

Patterns

Stability and Change

Transfer Goals

Transfer Goals

This unit builds on the chemical equilibrium content studied in Unit 7. Chemical equilibrium plays an important role in acid-base chemistry and solubility. The proton-exchange reactions of acid-base chemistry are reversible reactions that reach equilibrium quickly, and much of acid-base chemistry can be understood by applying the principles of chemical equilibrium. Most acid-base reactions have either large or small values of K, which means the qualitative conclusions regarding equilibrium state can often be drawn without extensive computations. The dissolution of a solid in a solvent can also be understood by applying the principles of chemical equilibrium because it i a reversible reaction that often reaches equilibrium quickly. In the final unit, the equilibrium constant is related to temperature and the difference in Gibbs free energy between the reactants and products.

Concepts

Big Idea 2 Structure and Properties

Essential Questions

What is an acid?

What is a base?

What is the pH concept?

What are Kw, Ka, Kb, pKa, pKb?

How do we solve acid-base equilibrium problems?

Do salts affect pH?

What are buffers?

How can we calculate concentrations in a buffered system?

What is buffer capacity?

Understandings

SAP-9 The chemistry of acids and bases involves reversible proton-transfer reactions, with equilibrium concentrations being related to the strength of the acids and bases involved.

SAP-10 A buffered solution resists changes to its pH when small amounts of acid or base are added.

Critical Knowledge and Skills

Knowledge

SAP-9.A Calculate the values of pH and pOH, based on K_w and the concentration of all species present in a neutral solution of water.

SAP-9.B Calculate pH and pOH, based on the concentrations of all species present in a solution of a strong acid or a strong base.

SAP-9.C Explain the relationship among pH, pOH and concentrations of all species of a monoprotic weak acid or weak base.

SAP-9.D Explain the relationship among the concentrations of major species in a mixture of weak and strong acids and bases.

SAP-9.E Explain the results from the titration of a mono- or polyprotic acid or base solution, in relation to the properties of the solution and its components.

SAP-9.F Explain the relationship between the strength of an acid or base and the structure of the molecule or ion.

SAP-10.A Explain the relationship between the predominant form of a weak acid or base in a solution given pH and the pKa of the conjugate acid or the pKb of the conjugate base.

SAP-10.B Explain the relationship between the ability of a buffer to stabilize pH and the reactions that occur when an acid or base is added to a buffered solution.

SAP-10.C Identify the pH of a buffer solution based on the identity and concentrations of the conjugate acid-base pair used to create the buffer.

SAP-10.D Explain the relationship between the buffer capacity of a solution and the relative concentrations of the conjugate acid and the conjugate base components of the solution.

Skills

5.B Identify an appropriate theory, definition, or mathematical relationship to solve a problem.

5.C Explain the relationship between variables within an equation when one variable changes.

5.F Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (eg, performing dimensional analysis and attending to significant figures).

5.D Identify information presented graphically to solve a problem.

6.C Support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules.

2.D Make observations or collect data from representations of laboratory set ups or results, while attending to precision where appropriate.

6.D Provide reasoning to justify a claim using chemical principles or laws, or using mathematical

justification.

6.G Explain how potential sources of experimental error may affect the experimental results.

Assessment and Resources

School Formative Assessment Plan (Other Evidence)

Ch 18 and 19 HW Sets

AP Classroom videos

AP Classroom Quizzes

AP Lab #14: Acid-Base pH Titration

AP Lab #15: Buffers in Household Products

School Summative Assessment Plan

Ch 18 and 19 Test

Primary Resources

Brown, Lemay, Bursten, et al. Chemistry: The Central Science (online)
Silberberg, Chemistry

AP Classroom

Supplementary Resources

Demin, AP Chemistry Multiple Choice and Free Response

Pearson Education, AP Chemistry

Flinn AP Chemistry Labs

Bozeman Science: AP Chemistry (YouTube)

Technology Integration and Differentiated Instruction

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Technology Integration

- **Vernier Graphical Analysis software and pH probes**

- **AP Classroom**
    - Topic Questions
    - Topic Videos
    - Topic Quizzes
    - Personal Progress Checks

- **Google Products**
    - Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
    - GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

- **One to One Student's laptop**
    - All students within the West Deptford School District are given a computer, allowing for 21st century learning to occur within every lesson/topic.

- **YouTube videos, tutorials, lab technique examples**

- **Additional Support Videos**

The videos below are just examples of videos that can be used to support each of the Lessons within this Topic.

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

Math

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
MA.N-RN.A	Extend the properties of exponents to rational exponents.
MA.N-RN.A.1	Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents.
MA.N-RN.A.2	Rewrite expressions involving radicals and rational exponents using the properties of exponents.
MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
MA.S-ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
MA.S-ID.A.4	Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.
MA.S-ID.B	Summarize, represent, and interpret data on two categorical and quantitative variables
MA.S-ID.B.5	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
MA.S-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
MA.S-ID.B.6a	Fit a function to the data (including with the use of technology); use functions fitted to data to solve problems in the context of the data.
MA.S-ID.B.6b	Informally assess the fit of a function by plotting and analyzing residuals, including with the use of technology.

MA.S-ID.B.6c	Fit a linear function for a scatter plot that suggests a linear association.
MA.S-ID.C	Interpret linear models
MA.S-ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
MA.S-ID.C.8	Compute (using technology) and interpret the correlation coefficient of a linear fit.

ELA

LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
LA.RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.

Learning Plan / Pacing Guide

Week 1:

Arrehnius and Bronsted-Lowry definitions

Conjugate Acid-Base systems

pH and pOH concept, Kw

pX and pKX

Strong Acids, Strong Bases

Weak acids and bases

Week 2:

Mixtures of acids and bases

Polyprotic Acids and Bases

Salts

Cations as Acids

Anions as Bases

Atomic structures of acids

Acid-Base Properties of Oxides

Lewis Acids and Bases

Week 3:

Properties of buffers

Henderson-Hasselbalch Equation

Buffer Capacity

Unit 9: Thermodynamics and Electrochem

Content Area: **Science**
Course(s): **Generic Course, AP CHEMISTRY**
Time Period: **Marking Period 4**
Length: **3 weeks**
Status: **Published**

Standards and Phenomena

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS-PS1-3	Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
SCI.HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. Mathematical and computational thinking at the 9–12 builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. Patterns Energy and Matter Patterns

Science Standards

SCI.HS.PS1.B	Chemical Reactions
SCI.HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

Phenomena

9.1 Intro to entropy

9.2 Absolute entropy and entropy change

9.3 Gibbs free energy and thermodynamic favorability

9.4 Thermodynamic and kinetic control

9.5 Free energy and equilibrium

9.6 Coupled reactions

9.7 Galvanic and Electrolytic cells

9.8 Cell potential and Free energy

9.9 Cell potential under nonstandard conditions

9.10 Electrolysis and Faraday's Law

Science and Engineering Practices

Obtaining, Evaluating, and Communicating Information

Analyzing and Interpreting Data

Constructing Explanations and Designing Solutions

Planning and Carrying Out Investigations

Asking Questions and Defining Problems

Engaging in Argument from Evidence

Developing and Using Models

Using Mathematics and Computational Thinking

Disciplinary Core Ideas

SCI.HS.PS1.A	Structure and Properties of Matter
SCI.HS.PS1.B	Chemical Reactions
SCI.HS.PS2.B	Types of Interactions
SCI.HS.PS3.A	Definitions of Energy
SCI.HS.PS3.B	Conservation of Energy and Energy Transfer
SCI.HS.PS3.C	Relationship Between Energy and Forces
SCI.HS.PS3.D	Energy in Chemical Processes
SCI.HS.PS3.D	Energy in Chemical Processes
SCI.HS.ETS1.B	Developing Possible Solutions
SCI.HS.ETS1.C	Optimizing the Design Solution
SCI.HS.ETS1.C	Optimizing the Design Solution

Crosscutting Concepts

Energy and Matter

Cause and Effect

Structure and Function

Stability and Change

Patterns

Systems and System Models

Transfer Goals and Career Ready Practices

Transfer Goals

This Unit allows students to connect principles and calculations across Units 5-8. The thermodynamics of a chemical reaction is connected to both the structural aspects of the reaction and the macroscopic outcomes of the reaction. All changes in matter involve some form of energy change. One key determinant of chemical transformations is the change in potential energy that results from changes in electrostatic forces. Chemical systems undergo three main processes that change their energy: heating/cooling, phase transitions, and chemical reactions. Applying the laws of thermodynamics will allow students to describe the essential role of energy and explain and predict the direction of changes in matter.

Concepts

Big Idea 4 Energy

Essential Questions

Why are some reactions spontaneous and others are not?

What is entropy?

How so we calculate entropy?

What is Gibbs Free Energy?

What is the relationship between Gibbs Free Energy and equilibrium?

How can we predict if a reaction is spontaneous or not?

What is an electrochemical cell?

How can we calculate cell potential?

What is a galvanic cell?

What is a voltaic cell?

What is Farady's Law?

Understandings

ENE-4 Some chemical or physical processes cannot occur without intervention.

ENE-5 The relationship between ΔG° and K can be used to determine favorability of a chemical or physical transformation.

ENE-6 Electrical energy can be generated by chemical reactions.

Critical Knowledge and Skills

Knowledge

ENE-4.A Identify the sign and relative magnitude of the entropy change associated with chemical or physical processes.

ENE-4.B Calculate the entropy change for a chemical or physical process based on the absolute entropies of the species involved in the process.

ENE-4.C Explain whether a physical or chemical process is thermodynamically favored based on an evaluation of ΔG°.

ENE-4.D Explain, in terms of kinetics, why a thermodynamically favored reaction might not occur at a measurable rate.

ENE-5.A Explain whether a process is thermodynamically favored using the relationships between K, ΔG°, and T.

ENE-5.B Explain the relationship between external sources of energy or coupled reactions and their ability to drive thermodynamically unfavorable processes.

ENE-6.A Explain the relationship between the physical components of an electrochemical cell and the overall operational principles of the ell.

ENE-6.B Explain whether an electrochemical cell is thermodynamically favored, based on its standard cell potential and the constituent half-reactions within the cell.

ENE-6.C Explain the relationship between deviations from standard cell conditions and changes in the cell potential.

ENE-6.D Calculate the amount of charge flow based no changes in the amounts of reactants and products in an electrochemical cell.

Skills

6.C Support a claim with evidence from representations or models at the particulate level, such as the structure of atoms and/or molecules.

5.F Calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (eg, performing dimensional analysis and attending to significant figures).

6.E Provide reasoning to justify a claim using connections between particulate and macroscopic scales or levels.

6.D Provide reasoning to justify a claim using chemical principles or laws, or using mathematical justification.

4.D Explain the degree to which a model or representation describes the connection between particulate-level properties and macroscopic properties.

2.F Explain how modifications to an experimental procedure will alter results.

5.F calculate, estimate, or predict an unknown quantity from known quantities by selecting and following a logical computational pathway and attending to precision (eg. performing dimensional analysis and attending to significant figures)

6.D Provide reasoning to justify a claim using chemical principles or laws, or using mathematical justification.

5.B Identify an appropriate theory, definition, or mathematical relationship to solve a problem.

Assessment and Resources

School Formative Assessment Plan (Other Evidence)

Ch HW Sets

AP Classroom videos

AP Classroom quizzes

AP Lab # 16: Preparing and Testing an Effective Buffer

School Summative Assessment Plan

Ch 20 Thermochemistry and Ch 21 Electrochemistry Test

Primary Resources

Brown, Lemay, Bursten, et al. Chemistry: The Central Science (online)
Silberberg, Chemistry

AP Classroom

Supplementary Resources

Demin, AP Chemistry Multiple Choice and Free Response
Pearson Education, AP Chemistry

Flinn AP Chemistry Labs

Bozeman Science: AP Chemistry (YouTube)

Technology Integration and Differentiated Instruction

Technology Integration

- **AP Classroom**
    - Topic Questions
    - Topic Videos
    - Topic Quizzes
    - Personal Progress Checks

- **Google Products**
    - Google Classroom - Used for daily interactions with the students covering a vast majority of different educational resources (Daily Notes, Exit Tickets, Classroom Polls, Quick Checks, Additional Resources/ Support, Homework, etc.)
    - GAFE (Google Apps For Education) - Using various programs connected with Google to collaborate within the district, co-teachers, grade level partner teacher, and with students to stay connected with the content that is covered within the topic. Used to collect data in real time and see results upon completion of the assignments to allow for 21st century learning.

- **One to One Student's laptop**
    - All students within the West Deptford School District are given a computer, allowing for 21st century learning to occur within every lesson/topic.

- **YouTube videos, tutorials, lab technique examples**

- **Additional Support Videos**

The videos below are just examples of videos that can be used to support each of the Lessons within this Topic.

Differentiated Instruction

Gifted Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, the Gifted Students are given choice on topic and subject matter allowing them to explore interests appropriate to their abilities, areas of interest and other courses.

English Language Learners (N.J.A.C.6A:15)

❑ Within each lesson, the English Language Learners are given choice of topic and resources so that their

materials are within their ability to grasp the language.

❑ All assignments have been created in the student's native language.

❑ Work with ELL Teacher to allow for all assignments to be completed with extra time.

At-Risk Students (N.J.A.C.6A:8-4.3c)

❑ Within each lesson, the at-risk students are given choice of topic and resources so that their materials are within their ability level and high-interest.

Special Education Students (N.J.A.C.6A:8-3.1)

❑ Within each lesson, special education students are given choice of topic and resources so that their materials are within their ability level and high-interest.

❑ All content will be modeled with examples and all essays are built on a step-by-step basis so modifications for assignments in small chunks are met.

All other IEP modifications will be honored (ie. hard copies of notes, directions restated, etc.)

Interdisciplinary Connections

SOCIAL STUDIES - Discuss advances in science and the impact they have on society

WORLD LANGUAGES - explore the etymology of chemistry related terms to gain an understanding of their meaning and relationships and other terms. Include topic-related articles within lessons.

VISUAL/PERFORMING ARTS - prepare and present multimedia presentations

APPLIED TECHNOLOGY - use online tools and applications for data analysis (Google Sheets, Vernier Data Analysis)

BUSINESS EDUCATION - when appropriate, relate topics to business and industry (chemical production, increasing product yields, alternative resources, etc)

GLOBAL AWARENESS - discuss the impact of diverse contributions to chemistry. Discuss the impact and relationship of chemistry on global issues (Climate Change, Fuels, Access to clean water)

ELA

LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.4	Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.
LA.RST.11-12.5	Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
LA.RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.10	By the end of grade 12, read and comprehend science/technical texts in the grades 11-CCR text complexity band independently and proficiently.
LA.WHST.11-12.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

MATH

MA.N-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
MA.N-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
MA.N-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
MA.N-RN.A	Extend the properties of exponents to rational exponents.
MA.N-RN.A.1	Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents.
MA.N-RN.A.2	Rewrite expressions involving radicals and rational exponents using the properties of exponents.
MA.S-ID.A	Summarize, represent, and interpret data on a single count or measurement variable
MA.S-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
MA.S-ID.A.2	Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
MA.S-ID.A.3	Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
MA.S-ID.B.5	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.
MA.S-ID.B.6	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

MA.S-ID.B.6a	Fit a function to the data (including with the use of technology); use functions fitted to data to solve problems in the context of the data.
MA.S-ID.B.6b	Informally assess the fit of a function by plotting and analyzing residuals, including with the use of technology.
MA.S-ID.B.6c	Fit a linear function for a scatter plot that suggests a linear association.
MA.S-ID.C	Interpret linear models
MA.S-ID.C.7	Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.
MA.S-ID.C.8	Compute (using technology) and interpret the correlation coefficient of a linear fit.

Learning Plan / Pacing Guide

Week 1:

Intro to entropy

Absolute entropy and entropy change

Gibbs free energy and thermodynamic favorability

Week 2:

Thermodynamic and kinetic control

Free energy and equilibrium

Coupled reactions

Week 3:

Galvanic and Electrolytic cells

Cell potential and Free energy

Cell potential under nonstandard conditions

Electrolysis and Faraday's Law