Audubon Public Schools

Chemistry

Curriculum Guide

Developed by:

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Course Description

Chemistry

Chemistry with Lab – Grades 10, 11 5 Credits/Full Year

Prerequisite: Students must have successfully completed CP/H Algebra & CP/H Geometry with an 86 or better and with teacher recommendation.

Chemistry with Lab offers the student an in depth study of matter and the changes it undergoes. The course content includes the study of the identification of elements, chemical reactions, acids and bases, properties of solids liquids and gases, and the mathematical relationships of each. Because of the highly mathematical content of this course, a grade of 86 or above in both CP/H Algebra I and CP/H Geometry are required as prerequisites. Students should have a working knowledge of percent, ratio, proportions, graphing, solving for unknowns in an algebraic equation and the ability to solve word problems. Students will be working on computer based activities, presentations, and demonstrations. In addition, a great emphasis is placed on laboratory investigations and safety in the lab. Written lab reports are required for most lab activities.

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Overview / Progressions

Grades 10-12: Chemistry

Overview	**Physical Sciences**
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Unit 2 Atomic Structure and Nuclear Chemistry	**HS-PS1-1, HS-PS1-4, HS-PS1-8, HS-PS1-3, HS-PS1-7, HS-PS1-5, HS-PS1-2**
Unit 3: Periodicity and Atomic Emission Spectra	**HS-PS1-1, HS-PS1-4, HS-PS1-8, HS-PS1-3, HS-PS1-7, HS-PS1-5, HS-PS1-2, HS-PS1-6**
Unit 4 Bonding & Chemical Reactions	**HS-PS1-7, HS-PS1-4, HS-PS1-5, HS-PS1-6, HS-ETS1-2.**
Unit 5 Mole Conversion Problems and Stoichiometry	**HS-PS1-1, HS-PS1-2 , HS-PS1-3, HS-PS1-5, HS-PS1-8, HS-PS1-4, HS-PS1-7, HS-PS1-6**
Unit 6 Solids, Liquids, Gases and Aqueous Solutions	**HS-PS1-5, HS-PS1-2, HS-PS1-6, HS-PS1-5, HS-PS1-4, HS-PS1-7**

Chemistry	Grade 10-12	Unit 1	Marking Period 1

Unit 1: Study of Matter Using Experimental Methods (36 Instructional Days)

UNIT SUMMARY:

As an overview:

1. The purpose of this unit is to make students aware of chemistry in their everyday lives, learn how to think like a scientist, and retain general knowledge of safe lab practices. Problem solving skills and introductions to mathematical concepts in chemistry will also be discussed.
2. The course opens up with this unit in order to ease the student into the general, overreaching nature of chemistry as a central science. Content from this unit gives the student an overview of the course and important introductory skills. In addition, this unit will strengthen the student's mathematical and problem solving skills that can be used in this course and daily life.
3. Without a foundational knowledge about chemistry and mathematics, students will not be able to grasp the importance of future content and skills introduced in later units.

Overarching Essential Questions	Overarching Enduring Understandings
• Which science is the most important: Physics, Biology or Chemistry? • What determines whether a substance will be a solid, liquid, or gas? • How is the separation of mixtures critical to our economy and standard of living? • What is the source of elements and what does that mean about the history of the universe? • Could there be undiscovered elements existing in outer space? • Why is it important to differentiate between elements and compounds? • Can the history of the Earth be told with Chemistry? • How can we use scientific thinking to solve everyday problems? • How do scientists conduct measurements?	Students will understand that… **Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5) **Energy and Matter** ● In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

	● The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)
Student Learning Objectives	
● Name and characterize the three states of matter ● Describe how the physical properties of solids, liquids, and gases depend on the ways in which the atoms, ions, or molecules of the substances are arranged, and by the strength of the forces of attraction between the atoms, ions, or molecules. ● Use quantitative and qualitative descriptors to describe matter ● Distinguish between a physical and chemical change ● Classify matter substances or mixtures and as homogeneous or heterogeneous ● Identify laboratory techniques used to separate mixtures ● Explain the difference between an element and a compound. ● Know that the properties of compounds are different from the properties of the individual elements that comprise the compound ● There is a vast history of discovering elements that continues with laboratory work today. ● Distinguish between an element symbol and a chemical formula. Know the names and symbols of common elements. ● Describe the ways in which elements are assigned names and symbols, and some ways in which new elements have been discovered	**PS1.A: Structure and Properties of Matter** ● Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) ● The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) ● The structure and interactions of matter at the bulk scale are determined by electrical forces within

• Identify the planetary location of different elements. • Explain which elements are found in each layer of the Earth. • The history of the Earth's formation can be explained using scientific reasoning and evidence from earth materials, meteorites and other planetary surfaces • Identify the different layers of the Earth and the composition of each. • Begin to discuss how the composition of some of those layers is changing. • Discuss elements and the possibility of unknown elements present in our solar system and beyond. • Distinguish between accuracy and precision of scientific measurements. • Use statistical analysis such as percent error and standard deviation to characterize error in an experiment • Know the SI units of measurement • Use dimensional analysis and conversion factors to convert between different units of measurements.	and between atoms. (HS-PS1-3),(secondary to HS-PS2-6) • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) **Planning and Carrying Out Investigations** • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider	**PS1.A: Structure and Properties of Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3) **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) **Constructing Explanations and Designing Solutions** • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-ETS1-3) **Obtaining, Evaluating, and Communicating Information** • Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)	columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) ● The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (*secondary to HS-PS2-6*) **PS1.B: Chemical Reactions** ● The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2) **PS2.B: Types of Interactions** ● Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1),(secondary to HS-PS1-3)* **ESS2.D: Weather and Climate**	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4) - ***Connections to Engineering, Technology, and Applications of Science* Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)

Using Mathematics and Computational Thinking • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4)	● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) **ETS1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) ● Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)	

Embedded English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2),(HS-ETS1-3)
WHST.9-12.7	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. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-3)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics

MP.2	Reason abstractly and quantitatively. (HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-ETS1-3),(HS-ETS1-4)
HSN-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. (HS-PS1-2),(HS-PS1-3)

Three-Dimensional Teaching and Learning
In this unit, students will expand their understanding of matter and its properties. Through the use of models, drawings, and computer simulations, the students will conclude that different substances are composed from different arrangement of atoms.In addition, students will develop an understanding that different substances have different properties. Students will then use the differences in properties to create a classification system for different types of substances. By employing this classification system, the students will be able to categorize materials as pure substances or mixtures and then further organize the substances as elements, compounds, heterogeneous mixtures, or homogeneous mixtures. Besides classifying substances by composition, scientists also categorize substances by their physical state (solid, liquid, or gas). Through the use of experiments (such as generating and analyzing a phase diagram by melting ice), models, diagrams, and computer simulations, students will be able to explain that the state of matter is related to the kinetic energy of the particles within the system and that during phase changes the energy is associated with forming or breaking the forces that occur between particles (intermolecular forces). By employing cause and effect relationships, models to represent the atomic scale, and the relationship between molecular structure and material function, the students will be able to collaboratively obtain, evaluate, summarize, and communicate information using the scientific process.

Prior Learning
Physical Science ● Substances are made from different types of atoms, which combine with one another in various ways. ● Atoms form molecules that range in size from two atoms to thousands of atoms. ● Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. ● Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. ● In a liquid, the molecules are constantly in contact with others. ● In a gas, the molecules are widely spaced except when they happen to collide. ● In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

- Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, whereas others store energy.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.
- These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting point of rocks.

Biology

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used, for example, to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another.
- Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
- Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Earth and Space Science

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

- Concept 1**:** Classification of Matter

Concepts	**Resources**	**Formative Assessment**
• How is matter classified? • What is the difference between an element, compound, and mixture? • Students will explore the nature of matter, its classifications, and its system for naming types of matter.	Animations/Videos State of matter Physical vs. Chemical Change Evaporation vs. Boiling Phase Changes Gases and Liquids Science Games https://youtu.be/KCL8zqjXbME – Video that explains the different types of matter	*Students who understand the concepts are able to:* • Contrast physical and chemical properties for substances • Contrast between physical and chemical changes for substances • Categorize substances based on their properties • Solve for the density of various objects by measuring their mass and volume and predict the type of matter for these objects through comparison to known densities

Concept 2: Kinetic Molecular Theory

Concepts	Resources	Formative Assessment
• The motion of particles is affected by the amount of energy contained in the system • Temperature is a measurement of the average kinetic energy of the particles • Adding thermal energy increases the kinetic energy of the particles • Removing thermal energy decreases the kinetic energy of the particles • Solids are composed of particles with low energy that are in contact with each other; the particles in a solid vibrate in place • Liquids are composed of particles that have more energy than a solid, these particles have the ability to move around freely, but are still in contact with each other (often colliding into each other) • Gases are composed of particles with a large amount of kinetic energy; the particles in a gas are spread out and rarely come in contact with each other • Phase changes occur when the intermolecular forces between particles can or cannot overcome the kinetic energy of the particles	• Prentice Hall: "Chemistry" Wilbraham et al, Boston, MA, 2008. Chapters: 1, 2 and 3. • Composition and Names of Earth's layers • How the EArth was formed • Core Sampling Video • KMT • Modeling the Kinetic Theory Additional Resources http://sciencespot.net/Pages/startersphysci.html http://www.chemtutor.com/ https://phet.colorado.edu/sims/html/build-an-atom/latest/build-an-atom_en.html www.quia.com www.edpuzzle.com www.quizlet.com http://www.interactivesolutions.co.uk/games/flashGames/labHazards.htm http://www.glencoe.com/sites/common_assets/science/virtual_labs/E17/E17.swf http://goo.gl/ZKaRFO - Matter Lab - Phet simulation	*Students who understand the concepts are able to:* • At home activity: ice cube melting experiment • Activity: determining density graphically • Lab: Separation of a Mixture • Lab: Density Determination • Lab: Measurements of mass and volume • Lab: Observing a Chemical Reaction • Activity: Core Sampling-create a model formation and "drill" for samples. • Chapter Quizzes, Unit Test

Modifications: ***Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.(See NGSS Appendix D)***

- *Restructure lesson using UDL principles (*http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA*)*
- *Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.*
- *Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques- auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).*
- *Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).*
- *Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).*
- *Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.*
- *Use project-based science learning to connect science with observable phenomena.*
- *Structure the learning around explaining or solving a social or community-based issue.*
- *Provide ELL students with multiple literacy strategies.*
- *Collaborate with after-school programs or clubs to extend learning opportunities*

Leveraging English Language Arts/Literacy and Mathematics

English Language Arts/Literacy-

- Create and present written descriptions to accompany the models developed
- Develop flow charts to assist in classification of substances

Mathematics-

- Calculate density after measuring mass and volume

• Apply graphical analysis to determine the relationship between energy, temperature, and the phase of substances

Samples of Open Education Resources for this unit:
States of matter simulation-an online simulation to reinforce the relationship between energy, temperature, and the phases of matter
Density simulation-an online simulation to investigate the physical property of density
Brainpop-properties of matter-videos and online activities for students related to physical and chemical properties
Brainpop-compounds and mixtures-videos and online activities that help students practice classifying matter

Chemistry	**Grade 10-12**	**Unit 2**	**Marking Period 1**

Unit 2 Atomic Structure and Nuclear Chemistry

UNIT SUMMARY:

As an overview:

- Describe the structure of atom including the charge and location of subatomic particles, the distribution of mass and volume within the atom, and the role of electrostatic and nuclear forces.
- Using the Periodic Table of Elements, determine the number of protons, neutrons and electrons and the atomic mass of any element.
- Describe the differences between alpha, beta and gamma radiation in terms of changes to the nucleus, types of damage caused and levels of penetration.
- Know that the amount of energy released during a nuclear reaction (fission or fusion) is much greater than the amount of energy released during a chemical reaction (as calculated by $E = mc^2$).
- Know that some naturally occurring isotopes are radioactive, as are isotopes formed in nuclear reactions.

Overarching Essential Questions	Overarching Enduring Understandings
● How do we know what we cannot see? ● Is all matter the same? ● How do surprises advance understanding? ● Are all forms of radiation harmful? ● Is nuclear power worth the risk? ● How does nuclear chemistry affect your everyday life? ● Why is nuclear power essential for many fields of medicine? ● How can nuclear power be useful as a future source of energy? ● What happens when matter absorbs different types of radiation? ● How is radiation converted into thermal and electrical energy through technology?	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1- 3),(HS-PS1-5) **Energy and Matter** ● In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) ● The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)

	● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) **PS1.A: Nuclear Processes** Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. **PS1.C: Nuclear Processes** Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.
Student Learning Objectives	

• Describe the evolution and refinement of modern atomic theory with a focus on benchmark experiments (CRT, gold foil, AES, and Millikan oil drop) and the scientific process. • Define nuclear reactions and identify the three different types of radiation that can be given off; alpha, beta and gamma radiation. • Distinguish between protons, electrons and neutrons in terms of their location in the atom, their, mass and their charge. Apply these ideas to the mass number, atomic number, isotopes and nuclear symbol. • Use a band of stability graph to predict the stability of a given nucleus based on its numbers of protons and neutrons and to predict the most likely form of decay for an unstable nucleus. • Write and balance nuclear reactions to show the conservation of mass and distinguish between chemical equations and nuclear equations applying the matter energy relationship. ($e=mc^2$) • Calculate the amount of nuclear material remaining using half-life and first order decay equations. List examples of how the half-life of an isotope can determine its usefulness applications like radioactive dating, medicine etc. • Use radioactive dating to determine the age of objects found on Earth and relate to history of Earth's development • Compare and contrast fission and fusion reaction • Explain how elements are created in the sun, in super nova's or in the lab. • Explain the processes that go on inside a nuclear reactor • Consider the pro's and con's of nuclear power including its role as an energy source for the future. • Explain how nuclear chemistry is used in different fields of medicine and the treatment of illnesses.	**Students will know…** HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Modeling in 9-12 builds on K-8 and progresses to using, synthesizing,	**PS1.A: Structure and Properties of Matter**	**Patterns**

and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8) ● Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) **<u>Planning and Carrying Out Investigations</u>** ● 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. ● Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)	● Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) ● The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) ● The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (*secondary to HS-PS2-6*) **<u>PS1.B: Chemical Reactions</u>** ● The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2)	● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3) **<u>Structure and Function</u>** ● Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6) **<u>Systems and System Models</u>** ● Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4) - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)

Constructing Explanations and Designing Solutions 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. ● Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) ● Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources	**PS2.B: Types of Interactions** ● Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1),(secondary to HS-PS1-3)* **ESS2.D: Weather and Climate** ● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) **ETS1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) ● Both physical models and computers can be used in various ways to aid in the engineering design process.	

of evidence, prioritized criteria, and trade off considerations. (HS-PS1-6) **Obtaining, Evaluating, and Communicating Information** • Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Using Mathematics and Computational Thinking** • Mathematical and computational thinking at the 9-12 level 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. ● Use mathematical representations of phenomena to support claims. (HS-PS1-7)	Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)	

Embedded English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2),(HS-ETS1-3)
WHST.9-12.7	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. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-3)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics

MP.2	Reason abstractly and quantitatively. (HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-ETS1-3),(HS-ETS1-4)
HSN-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. (HS-PS1-2),(HS-PS1-3)

Three-Dimensional Teaching and Learning
In this unit, students will expand their understanding of matter and its properties. Through the use of models, drawings, and computer simulations, the students will conclude that different substances are composed from different arrangement of atoms.In addition, students will develop an understanding that different substances have different properties. Students will then use the differences in properties to create a classification system for different types of substances. By employing this classification system, the students will be able to categorize materials as pure substances or mixtures and then further organize the substances as elements, compounds, heterogeneous mixtures, or homogeneous mixtures. Besides classifying substances by composition, scientists also categorize substances by their physical state (solid, liquid, or gas). Through the use of experiments (such as generating and analyzing a phase diagram by melting ice), models, diagrams, and computer simulations, students will be able to explain that the state of matter is related to the kinetic energy of the particles within the system and that during phase changes the energy is associated with forming or breaking the forces that occur between particles (intermolecular forces). By employing cause and effect relationships, models to represent the atomic scale, and the relationship between molecular structure and material function, the students will be able to collaboratively obtain, evaluate, summarize, and communicate information using the scientific process.

Prior Learning
Physical Science ● Substances are made from different types of atoms, which combine with one another in various ways. ● Atoms form molecules that range in size from two atoms to thousands of atoms. ● Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. ● Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. ● In a liquid, the molecules are constantly in contact with others. ● In a gas, the molecules are widely spaced except when they happen to collide. ● In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.

- Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, whereas others store energy.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.
- These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting point of rocks.

Biology

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used, for example, to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another.
- Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
- Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Earth and Space Science

● The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

● Concept 1**:** Atomic Theory		
Concepts	**Resources**	**Formative Assessment**
● Define the term **atom** ● Distinguish between **protons, neutrons & electrons** ○ know that protons & neutrons are collectively called nucleons ● Define **atomic number & atomic mass** ○ Know that C-12 is the standard used to determine the atomic mass of all other atoms in amu's ○ Know that the mass of C-12 in amu's is exactly 12 ● Use a **periodic table** to determine the correct number of protons, neutrons & electrons in a particular atom ● Be able to define an **isotope** ○ Distinguish between isotopes of an element ● Interpret notation for isotopes of an element	Prentice Hall: "Chemistry" Wilbraham et al, Boston, MA, 2008. Chapters 4 and 25	● Lab: Candium (use candy to demonstrate how an average atomic mass is calculated) ● Lab: Mass Spectrometry

● Determine the **average atomic mass** of an element, given isotopic abundances & masses ● Define the terms **ion, cation & anion** ● Calculate the number of protons, neutrons & electrons in ions **Atomic Theory:** ● List the basic ideas of **Dalton's atomic theory** ● Describe **Thomson's model** of the atom ● Describe **Rutherford's model** of the atom & interpret his famous experiment ○ Be able to discuss Rutherford's conclusion regarding the structure of the atom ● Describe the **Bohr model** of the atom ● In the modern or quantum theory of the atom, know what the term **orbital** means & how it differs from an **orbit**		

Concept 2: Nuclear Chemistry		
Concepts	**Resources**	**Formative Assessment**
● Define **radioactivity** ○ define the term **natural radioactivity** ■ know that natural radioactivity & natural transmutation mean the same thing ● Identify the naturally occurring radioactive elements ● List the characteristics (mass, charge & penetration power) & symbols of the major nuclear emanations: **alpha particle, beta particle, positron, gamma radiation, proton, neutron & electron** ○ Be able to write equations for the generation of alpha particles, beta particles & positron particles ○ Be able to describe towards which electrode (+/-) particles will move when a radioactive beam is passed between them ● Be able to determine the **decay mode** of a specific isotope using your reference tables	● Prentice Hall: "Chemistry" Wilbraham et al, Boston, MA, 2008. Chapters 4 and 25 ● Composition and Names of Earth's layers: https://www.space.com/17777-what-is-earth-made-of.html ● How the EArth was formed: https://www.khanacademy.org/science/biology/history-of-life-on-earth/history-life-on -earth/v/earth-formation ● Core Sampling Video: https://www.youtube.com/watch?v=yiVoRsWzI3c	● ● Lab: Radioactive Decay with Pennies ● Activity: 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. ● Activity: Class debate on nuclear power ● Activity: Calculate annual nuclear radiation exposure from different environmental sources ● Draw or label a diagram of a nuclear reactor. Explain each step in the process. ● Essay test on benchmark experiments including Rutherford Gold foil, Cathode Ray tube and Oil Drop experiment. ● Chapter Quizzes, Unit Test

○ Be able to determine the decay mode from a nuclear reaction when given the natural transformation of one element to another ○ Be able to explain what a decay series is ○ Be able to write & balance nuclear equations for natural transmutations ● Define **natural transmutation** ○ Know the difference between natural & artificial transmutation ○ Know how to identify, write & balance **nuclear equations** for both types ● Define **half-life** ○ Solve problems using half-life ■ Be able to calculate how much material remains after some specific number of half-lives ■ Given the starting amount of material & the ending amount of material determine the number of half-lives that have passed		

■ Be able to calculate half-life given time passes & starting & ending amounts of material ○ Know that half-life is not affected by either temp or how much of the element is present ● Solve problems involving half-life and **fraction remaining** ● Know the difference between **fission & fusion** ○ Identify fission & fusion equations based on their nuclear equations ● Understand the benefits & dangers of radioactive isotopes ○ Know the medical benefits of I-131 for thyroid disorders, Tc-99 for brain tumors & Co-60 for certain cancer treatment & detection ● Know that all isotopes above atomic number 83 are all radioactive		

Modifications: ***Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.(See NGSS Appendix D)***

- *Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)*
- *Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.*
- *Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques- auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).*
- *Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).*
- *Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).*
- *Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.*
- *Use project-based science learning to connect science with observable phenomena.*
- *Structure the learning around explaining or solving a social or community-based issue.*
- *Provide ELL students with multiple literacy strategies.*
- *Collaborate with after-school programs or clubs to extend learning opportunities*

Leveraging English Language Arts/Literacy and Mathematics

- ***Interdisciplinary Connections***
    - *History: Connect scientific discoveries in various countries to the political and cultural climate in each location*
    - *Mathematics: Statistical analysis of data collected.*
    - *Earth Science: Use radioactive dating to determine the age of the Earth*
- ***Technology Integration***
    - *Use spreadsheet and other analysis tools to examine the relationships of atoms on periodic table*

- *Use video animations to show setup of historical experiments (Gold foil, Milikan oil drop) Media Literacy Integration*
- *Use video clips and articles to stimulate interest in the topic eg. Frontline Video: Radioactive Wolves, Fukushima Meltdown*
- *Compare scientifically reviewed articles (e.g. Nature) to popular literature (e.g. Newsweek) for the same breakthrough. Relate this to the development of atomic theory.*

- ***Global Perspectives***
  - *Discuss the use of nuclear power and other in various countries.*
  - *Global sources of oil, uranium, plutonium*

Samples of Open Education Resources for this unit:

Chemistry	**Grade 10-12**	**Unit 3**	**Marking Period 2**

Unit 3
Electrons in Atoms, Atomic Emission and Periodicity

UNIT SUMMARY:
As an overview:

- Atomic Models and Electromagnetic Energy
  - Distinguish between the Rutherford, Bohr, and Quantum-Mechanical Models of the atom
  - Use the wave equation and Planck's Law to calculate wavelength, frequency, and energy of a photon.
  - Explain the mechanism responsible for emission and absorption spectra of elements
- Electron Configurations and the Quantum-Mechanical Model
  - Write electron configuration of neutral atoms in the ground state
  - Explain Aufbau Principle, Pauli Exclusion Principle, and Hund's Rule
- The Periodic Table and Periodic Trends
  - Identify metals, nonmetals, transition metals, and metalloids on the periodic table
  - Define cation and anion. Predict whether an element is likely to become a cation or anion based on its position on the periodic table.
  - Predict Periodic trends for atomic size, ionization energy, and electronegativity Explain the periodic trends

Overarching Essential Questions	Overarching Enduring Understandings
● How do we know what we can not see? ● Is all matter the same? ● How do scientific surprises advance understanding? ● What is an atom and how has that definition changed over time? ● Is there evidence that exists that suggests our current model of the atom is not sufficient? ● Can scientists explain the processes that occur on the subatomic level? ● Is there use of trends as predictors in science useful or dangerous? ● Are all forms of radiation harmful?	● Atoms and molecules have substructures that are responsible for housing subatomic particles. These subatomic particles allow us to understand the differences between different objects we see around us. ● A conversion of mass into energy occurs during the nuclear processes of fission and fusion.

	Some elements are radioactive and they release particles and radiant energy into the environment.

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Modeling in 9-12 builds on K-8 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. ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8) ● Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) **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. ● Plan	**PS1.A: Structure and Properties of Matter** ● Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1) ● The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2) ● The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (*secondary to HS-PS2-6*) **PS1.B: Chemical Reactions**	Students will understand that… **Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)

and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) **Constructing Explanations and Designing Solutions** 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. ● Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) ● Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer	● The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2) **PS2.B: Types of Interactions** ● Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary to HS-PS1-1),(secondary to HS-PS1-3)* **ESS2.D: Weather and Climate** ● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) **ETS1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) ● Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are	**Energy and Matter** ● In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) ● The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) ● Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1) **Structure and Function** ● Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the

review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-PS1-6) **Obtaining, Evaluating, and Communicating Information** • Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Using Mathematics and Computational Thinking** • Mathematical and computational thinking at the 9-12 level 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	useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)	structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2- 6) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1) • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4) Systems can be designed to cause a desired effect. (HS-PS4-5)

and used based on mathematical models of basic assumptions. ● Use mathematical representations of phenomena to support claims. (HS-PS1-7)		**PS1.A: Structures and Properties of Matter** Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS4.A: Wave Properties** The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. **PS4.B: Electromagnetic Radiation** When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. **ESS1.A : The Universe and Its Stars** The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)

		ESS2.D: Weather and Climate The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. - ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)
Embedded English Language Arts/Literacy and Mathematics		
English Language Arts/Literacy		

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2),(HS-ETS1-3)
WHST.9-12.7	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. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-3)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)
Mathematics	
MP.2	Reason abstractly and quantitatively. (HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-ETS1-3),(HS-ETS1-4)
HSN-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. (HS-PS1-2),(HS-PS1-3)

Prior Learning

Physical Science

- Substances are made from different types of atoms, which combine with one another in various ways.
- Atoms form molecules that range in size from two atoms to thousands of atoms.
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- In a liquid, the molecules are constantly in contact with others.
- In a gas, the molecules are widely spaced except when they happen to collide.
- In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways.
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Biology

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
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- Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
- Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Earth and Space Science

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

- Concept 1**:** Periodic Table

Concepts	Resources	Formative Assessment
• What are the components of the periodic table and how to use them to locate and make predictions about elements including… ○ Their arrangement in the periodic table. ○ Atomic composition. ○ Electrons in the outermost energy level. ○ The number of protons in each element	Prentice Hall: "Chemistry" Wilbraham et al, Boston, MA, 2008. Chapters: 5 and 6 • IUPAC Periodic Table of Elements • Get the latest table straight from the source—IUPAC. Now with names and symbols for 113, 115, 117, and 118. • National Periodic Table Day • Is it February yet? Use these periodic tables to get	Students who understand the concepts are able to: • Write electron configurations for many elements on the periodic table. • Draw diagrams to represent the atomic theories throughout history. • Identify which isotope of an element is the most abundant based on average atomic mass.

	ready to celebrate this new chemistry holiday. ● TED-Ed and Periodic Videos ● One table. 118 videos. 118 lessons. Better get started. ● 112 Cartoon Elements ● Love comics? This collection of element drawings is for you, with each element turned into a cartoon character. Meet them all! ● The Elements ● Periodic table samples as far as the eye can see! Theo Gray's collection of images will pull you in. ● International Year of Chemistry Periodic Table Project ● It's a mural! It's an app! It's a poster! It's… element tiles created by chemistry students and enthusiasts. Find your favorite. These four are the latest additions. ● Periodic Table Database ● Periodic table alert! Spiral ones. 3-dimensional ones. Really old ones. Even non-chemical ones. (Ever heard of a "smellelement"?) ● Periodic table song video	● Calculate the average atomic mass of an element from its isotopic masses and relative abundance. ● Lab: Colorful Flames and Calculation of an Atomic Emission Spectrum ● Lab: Electron Configuration ● Lab: Periodic Trends ● Activity: Analyze line spectra from stars to determine composition of an unknown ● Project: Research different sources of radiation found on Earth and their uses. ● Chapter Quizzes, Unit Test

	• Interactive Periodic table from Annenberg Series	

Modifications: ***Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.(See NGSS Appendix D)***
• *Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)* • *Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.* • *Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques- auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).* • *Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).* • *Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).* • *Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.* • *Use project-based science learning to connect science with observable phenomena.* • *Structure the learning around explaining or solving a social or community-based issue.* • *Provide ELL students with multiple literacy strategies.*

Leveraging English Language Arts/Literacy and Mathematics
• ***Interdisciplinary Connections***

- *History: Connect scientific discoveries in various countries to the political and cultural climate in each location*
- *Mathematics: Statistical analysis of data collected.*
- *Earth Science: Use radioactive dating to determine the age of the Earth*

- ***Technology Integration***
  - *Use spreadsheet and other analysis tools to examine the relationships of atoms on periodic table*
  - *Use video animations to show setup of historical experiments (Gold foil, Milikan oil drop) Media Literacy Integration*
  - *Use video clips and articles to stimulate interest in the topic eg. Frontline Video: Radioactive Wolves, Fukushima Meltdown*
  - *Compare scientifically reviewed articles (e.g. Nature) to popular literature (e.g. Newsweek) for the same breakthrough. Relate this to the development of atomic theory.*
- ***Global Perspectives***
  - *Discuss the use of nuclear power and other in various countries.*
  - *Global sources of oil, uranium, plutonium*

Samples of Open Education Resources for this unit:

Chemistry	Grade 10-12	Unit 4	Marking Period 2

Unit 4
Bonding & Chemical Reactions

UNIT SUMMARY:
As an overview:
In this unit of study, students *develop and using models, plan and conduct investigations, use mathematical thinking*, and *construct explanations and design solutions* as they develop an understanding of the substructure of atoms and to provide more mechanistic explanations of the properties of substances. Chemical reactions, including rates of reactions and energy changes, can be understood by students at this level in terms of the collisions of molecules and the rearrangements of atoms. Students also apply an understanding of the process of *optimization and engineering design* to chemical reaction systems. The crosscutting concepts of *patterns, energy and matter*, and *stability and change* are the organizing concepts for these disciplinary core ideas. Students are expected to demonstrate proficiency in *developing and using models, planning and conducting investigations, using mathematical thinking*, and *constructing explanations and designing solutions*.
This unit is based on HS-PS1-7, HS-PS1-4, HS-PS1-5, HS-PS1-6, and HS-ETS1-2.

Overarching Essential Questions	Overarching Enduring Understandings
● Why do substances react? ● How can we use the language of Chemistry to refer to substances by name or by formula? ● How can we visually represent what is happening when a bond forms?	● Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of

● What determines the properties of substances, such as solubility in water and electrical conductivity? ● How can we represent a chemical reaction both quantitatively and qualitatively? ● What role does energy play in chemical reactions?	atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-2 ● 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. HS-PS1-4 ● 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. HS-PS1-5 ● Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. HS-PS1-6 ● Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. HS-PS1-7

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using,	**PS1.A: Structure and Properties of Matter**	**Patterns** ● Different patterns may be observed at each of the scales at

synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4) **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9–12 builds on K–8 experiences 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. • Use mathematical representations of phenomena to support claims. (HS-PS1-7)	• The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-2)*(Note: This Disciplinary Core Idea is also addressed by HS-PS1-1.)* • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) **PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4), (HS-PS1-5) • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse	which a system is studied and can provide evidence for causality in explanations of phenomena.(HS-PS1-2), (HS-PS1-5) **Energy and Matter** • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) **Connections to Nature of Science** Scientific Knowledge Assumes an Order and Consistency in Natural Systems • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)

Constructing Explanations and Designing Solutions 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. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.(HS-PS1-5) • Refine a solution to a complex real-world problem, based on scientific knowledge, student-	reaction determines the numbers of all types of molecules present. (HS-PS1-6) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2), (HS-PS1-7) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS1-6)*	

generated sources of evidence, prioritized criteria, and trade off considerations. (HS-PS1-6)		

Embedded English Language Arts/Literacy and Mathematics

English Language Arts/Literacy

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2),(HS-ETS1-3)
WHST.9-12.7	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. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-3)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)

Mathematics

MP.2	Reason abstractly and quantitatively. (HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-ETS1-3),(HS-ETS1-4)

HSN-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. (HS-PS1-2),(HS-PS1-3)

Prior Learning

Physical Science

- Substances are made from different types of atoms, which combine with one another in various ways.
- Atoms form molecules that range in size from two atoms to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others.
- In a gas, the molecules are widely spaced except when they happen to collide.
- In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).

- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, whereas others store energy.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.
- These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting point of rocks.

Biology

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used, for example, to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another.
- Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
- Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Earth and Space Science

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of

energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

- Concept 1**:** Periodic Table

Concepts	Resources	Formative Assessment
• Describe ion formation based on electron configuration • Distinguish between ionic and covalent bonds in terms of electron behavior as well as the properties of compounds that contain each type. • Recognize patterns of bonding from the periodic table. • Describe metallic bonding and how it affects the properties of metals • Describe properties and uses of different alloys • Identify the differences in properties between elements and the compounds that they form. • Predict chemical formulas of ionic compounds based on ion charges. • Write chemical formulas for ionic compounds, binary molecular compounds and acids and bases. • List the properties of acids and bases.	Prentice Hall: "Chemistry" Wilbraham et al, Boston, MA, 2008. Chapters: 7, 8, 9, 11, 19 and 20 1. Chemical Change and Physical Change- To learn that a chemical reaction occurs when two reactants combine to form a new product. 2. Chemical Changes- The students in grades 3-8 will be able to explore some properties of Chemical Changes. 3. Chemical Changes- The second grade students will investigate some chemical changes and reactions and should be able to identify at least four characteristics that indicate a chemical change. 4. Chemical Changes- To learn that the formation of gas	• Lab: Identify an Unknown Metal • Lab: Chemical Names and Formulas • Lab: Molecular Geometry • Lab: Types of Solids • Lab: Writing an Equation for a Chemical Reaction • Lab: Types of Chemical reactions • Activity: Balancing chemical reactions • Demonstrations for types of chemical reactions • Chapter Quizzes, Unit Test

• State and distinguish between the Arrhenius definition and the Bronsted Lowry definition of acids and bases. • Draw Lewis dot diagrams for atoms, monatomic ions, molecular compounds and polyatomic ions. • Describe and name the forces that hold molecules together. • Compare the strength of covalent bonds using bond dissociation data tables. • Calculate the energy change associated with the breaking and forming of all of the bonds in one mole of a substance. • Determine molecular polarity and describe its effect on the properties of a sample of matter. • Categorize solids as ionic, molecular, metallic, or network covalent. • Represent chemical change with balanced chemical equations. • Classify chemical reactions as combination, decomposition, combustion, single replacement, or double replacement (including neutralization reactions). • Distinguish between electron transfer reactions and ion exchange reactions.	bubbles is an indication of a chemical change. 5. Chemical Equilibrium- Distinguish between reactions that go to completion and those that are reversible. 6. Chemical Reactions - The topics I am going to cover in this lesson are atoms and chemical reactions. 7. Chemical Reaction Rates- To learn phenomenologically some of the factors which affect the rates of chemical reactions. 8. Chemical Reactions With Vinegar- To determine whether vinegar creates a chemical reaction.	

• Write molecular equations, complete ionic equations and net ionic equations. • Given a set of reactants, predict the products formed and write a balanced chemical equation for the reaction. • Show how human activity impacts the formation of acid rain. • Write balanced chemical equations for these reactions • Discuss the synthesis of new compounds such as pharmaceuticals through chemical reactions		

Modifications: ***Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.(See NGSS Appendix D)***

- *Restructure lesson using UDL principles (*http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA*)*
- *Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.*
- *Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques- auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).*
- *Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).*
- *Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).*

- *Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.*
- *Use project-based science learning to connect science with observable phenomena.*
- *Structure the learning around explaining or solving a social or community-based issue.*
- *Provide ELL students with multiple literacy strategies.*

Leveraging English Language Arts/Literacy and Mathematics

- ***Interdisciplinary Connections***
    - *History: Connect scientific discoveries in various countries to the political and cultural climate in each location*
    - *Mathematics: Statistical analysis of data collected.*
    - *Earth Science: Use radioactive dating to determine the age of the Earth*
- ***Technology Integration***
    - *Use spreadsheet and other analysis tools to examine the relationships of atoms on periodic table*
    - *Use video animations to show setup of historical experiments (Gold foil, Milikan oil drop) Media Literacy Integration*
    - *Use video clips and articles to stimulate interest in the topic eg. Frontline Video: Radioactive Wolves, Fukushima Meltdown*
    - *Compare scientifically reviewed articles (e.g. Nature) to popular literature (e.g. Newsweek) for the same breakthrough. Relate this to the development of atomic theory.*
- ***Global Perspectives***
    - *Discuss the use of nuclear power and other in various countries.*
    - *Global sources of oil, uranium, plutonium*

Samples of Open Education Resources for this unit:

Chemistry	Grade 10-12	Unit 5	Marking Period 2

Mole Conversion Problems and Stoichiometry

UNIT SUMMARY:
As an overview:
In Stoichiometry, it's important to know how to basic like finding the amount of weigh a product or reaction by using the periodic table. Another major role to master is the concept of knowing how to convert moles to mass and that to molar mass and vice versa. And the final essential tool that is highly required in Stoichiometry is to know how to balance ratios in reactions. Students will also learn how to identify, balance and write chemical equations. Students will learn how to make conversions from grams to moles to liters to atoms,ions,molecules, formula units. They will do this using guided practice and group work. Students will then use the molar coefficients in balanced equations along with their knowledge of unit conversions to convert from the value of one substance to another.

Overarching Essential Questions	Overarching Enduring Understandings
● How can the interpretation or manipulation of quantitative data be used to determine the chemical composition of a substance? ● How are balanced chemical equations used to calculate quantities of substances	● Construct and revise an explanation for the outcome of a simple chemical reaction based on

in chemical reactions? ● Why is it important that we are able to determine a limiting reactant? ● How can you choose a level of accuracy that is appropriate to limitations on measurement when reporting quantities?	the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. HS-PS1-2 ● 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. HS-PS1-4 ● Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. HS-PS1-7

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
● Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion ● Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables	Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. **PS1.B: Chemical Reactions**	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1), (HS-PS1-2) ,(HS-PS1-3), (HS-PS1-5) **Energy and Matter** ● In nuclear processes, atoms are not conserved, but the total number of

	• Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4), (HS-PS1-5) • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2), (HS-PS1-7) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of	protons plus neutrons is conserved. (HS-PS1-8) ● The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4) **Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) ● **PS1.A: Structure and Properties of Matter** The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS1.A: Structure and Properties of Matter** The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. A stable molecule has less energy than the

	certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS1-6)*	same set of atoms separated; one must provide at least this energy in order to take the molecule apart. **PS1.B: Chemical Reactions** The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. **PS3.A: Definitions of Energy** Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity

		called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. **PS2.B: Types of Interactions** Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. **ESS2.D: Weather and Climate** The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate
Embedded English Language Arts/Literacy and Mathematics		
English Language Arts/Literacy		

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WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-3)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)
Mathematics	
MP.2	Reason abstractly and quantitatively. (HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-ETS1-3),(HS-ETS1-4)
HSN-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. (HS-PS1-2),(HS-PS1-3)

Prior Learning

Physical Science

- Substances are made from different types of atoms, which combine with one another in various ways.
- Atoms form molecules that range in size from two atoms to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others.
- In a gas, the molecules are widely spaced except when they happen to collide.
- In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, whereas others store energy.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.
- These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting point of rocks.

Biology

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used, for example, to form new cells.

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another.
- Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
- Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Earth and Space Science

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

Stoichiometry		
Concepts	**Resources**	**Formative Assessment**
• Define the mole as a chemical quantity equal to Avogadro's number of representative particles. • Determine the molar mass of a substance • Relate mass, volume, particles and moles of a substance quantitatively and qualitatively • Perform multi-step problems to convert between units of mass, volume, representative particles and density	Prentice Hall: "Chemistry" Wilbraham et al, Boston, MA, 2008. Chapters: 10, 12 Activity 1: Intro to Chemical Reactions and Limiting Reactants Activity 2: Reactants, Products and Leftovers	• Lab: Limiting Reactant and Percent Yield • Lab: Counting by Measuring Mass • Lab: Empirical Formula of an Oxide or Empirical Formula of a Hydrate • Lab: Decomposition of Baking Soda • Chapter Quizzes, Unit Test

• Use balanced chemical equations to determine the mole ratio of substances in chemical reactions. • Use stoichiometry to identify the limiting reactant and excess reactant in a chemical reaction. Calculate theoretical yield and percent yield. • Given percent composition or mass data, determine the empirical and molecular formula of a compound. • Calculate the percent composition for a sample of material • Use balanced chemical equations to show the conservation of mass throughout a reaction • Choose a level of precision appropriate to limitations on measurement when reporting quantities. Report quantities with correct number of significant figures and correct units. • Analyze data and experimental techniques to appropriately discuss the error in a quantitative experiment.	Chemical reactions and stoichiometry video	

Modifications: ***Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.(See NGSS Appendix D)***

- *Restructure lesson using UDL principles (http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA)*
- *Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.*
- *Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques- auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).*
- *Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).*
- *Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).*
- *Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.*
- *Use project-based science learning to connect science with observable phenomena.*
- *Structure the learning around explaining or solving a social or community-based issue.*
- *Provide ELL students with multiple literacy strategies.*

Leveraging English Language Arts/Literacy and Mathematics

- ***Interdisciplinary Connections***
    - *History: Connect scientific discoveries in various countries to the political and cultural climate in each location*
    - *Mathematics: Statistical analysis of data collected.*
    - *Earth Science: Use radioactive dating to determine the age of the Earth*
- ***Technology Integration***
    - *Use spreadsheet and other analysis tools to examine the relationships of atoms on periodic table*

- *Use video animations to show setup of historical experiments (Gold foil, Milikan oil drop) Media Literacy Integration*
- *Use video clips and articles to stimulate interest in the topic eg. Frontline Video: Radioactive Wolves, Fukushima Meltdown*
- *Compare scientifically reviewed articles (e.g. Nature) to popular literature (e.g. Newsweek) for the same breakthrough. Relate this to the development of atomic theory.*

- ***Global Perspectives***
  - *Discuss the use of nuclear power and other in various countries.*
  - *Global sources of oil, uranium, plutonium*

Samples of Open Education Resources for this unit:

Unit 6: Solids, Liquids, Gases and Aqueous Solutions

UNIT SUMMARY:
As an overview:
Students will be able to explain kinetic molecular theory in relation to temperature, energy and molecular motion. These principles, as well as intermolecular forces, will be applied to changes of state. Students will be able to explain the effects of temperature, pressure, and volume upon gases and relate these effects to gas laws. Calculations will be made to quantify changes by using both gas law equations and stoichiometry.

Overarching Essential Questions	Overarching Enduring Understandings
● What factors affect the properties of the different states of matter? ● How can matter exist at different states at the same temperature and pressure? ● How is energy transferred between states of matter? ● Can changes in the behavior of matter be predicted? ● Has the composition of our atmosphere remained consistent over time? ● How is weather related to the energy transfer between different states of matter on Earth?	● Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) ● Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) ● Refine a solution to a complex

	real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (HS-PS1-6)

The Student Learning Objectives above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
• Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion • Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables	Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. **PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in	Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. **Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.(HS-PS1-2), (HS-PS1-5) **Energy and Matter** • The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) • Changes of energy and matter in a system can be described in terms of energy and matter flows into,

	kinetic energy. (HS-PS1-4), (HS-PS1-5) • In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2), (HS-PS1-7) **ETS1.C: Optimizing the Design Solution** • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary to HS-PS1-6)*	out of, and within that system. (HS-PS1-4) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6) **Connections to Nature of Science** Scientific Knowledge Assumes an Order and Consistency in Natural Systems • Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7)
Embedded English Language Arts/Literacy and Mathematics		
English Language Arts/Literacy		

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)
WHST.9-12.5	Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2),(HS-ETS1-3)
WHST.9-12.7	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. (HS-PS1-3)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-3)
SL.11-12.5	Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)
Mathematics	
MP.2	Reason abstractly and quantitatively. (HS-ETS1-3),(HS-ETS1-4)
MP.4	Model with mathematics. (HS-ETS1-3),(HS-ETS1-4)
HSN-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. (HS-PS1-2),(HS-PS1-3)

Prior Learning

Physical Science

- Substances are made from different types of atoms, which combine with one another in various ways.
- Atoms form molecules that range in size from two atoms to thousands of atoms.
- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others.
- In a gas, the molecules are widely spaced except when they happen to collide.
- In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. • Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, whereas others store energy.
- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics.
- These physical and chemical properties include water's exceptional capacity to absorb, store, and release large amounts of energy; transmit sunlight; expand upon freezing; dissolve and transport materials; and lower the viscosities and melting point of rocks.

Biology

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used, for example, to form new cells.

- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another.
- Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles.
- Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Earth and Space Science

- The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.

Stoichiometry

Concepts	Resources	Formative Assessment
Gases ● Define the properties of a gas in terms of the Kinetic Molecular Theory. ● Identify and define the factors that affect gas pressure ● Describe how Torricelli's barometer measured atmospheric pressure. ● Convert between units of pressure using dimensional analysis. ● Relate the Kelvin temperature scale to kinetic energy.	Prentice Hall: "Chemistry" Wilbraham et al, Boston, MA, 2008. Chapters: 13, 14, 15, 16 and 20 **Gases** Gas law resources Gas Law Notes Online Jeopardy	● Lab: Creating a Heating and Cooling Curve for Lauric Acid Lab ● Lab: Thinking About Gases ● Lab: Investigation of Gas Properties Lab ● Lab: Collecting a Gas over Water Lab ● Activity: Developing the Kelvin Temperature Scale ● Lab: Absorption Spectrum of Cobalt (II) Chloride Lab ● Lab: Electrolytes or Making a Solution

• Relate pressure, volume and temperature of a gas graphically and mathematically. • Discuss the contribution of Boyle, Charles and Gay-Lussac in the derivation of the combined gas law. • Evaluate Kinetic molecular theory by comparing real and ideal gases. • Relate pressure, temperature, volume and moles of gas to the ideal gas law. • Combine the ideal gas law with stoichiometry. • Use Dalton's law to calculate partial pressures. • Predict Relative Rates of Gas Diffusion using Graham's Law. Relate this law to the Kinetic energy of a substance. • Explain how the composition of the Earth's atmosphere has changed over time due to human activity • Review the different chemical reactions involved in the production of carbon dioxide in our atmosphere • Use models to explain how energy flow effects climate changes.	**Liquids** Dissolving: Electrolytes vs. Nonelectrolytes Dissociation vs Ionization Acids and Bases	• Lab: Titration of Vinegar • Lab: Colligative Properties (MM determination) • Demonstrations: surface tension, chromatography...etc • Activity: What is Oobleck? • Activity: Station Models; barometer, wind vane, anemometer and sling psychrometer • Activity: Highs and Lows, where does the weather go? • Chapter Quizzes, Unit Test **Technology Integration** • Excel used for data analysis and graphing. • Online tutorials and virtual labs can be used to for differentiation. **Media Literacy Integration** • Compare and contrast scientific articles on global warming and/or acid rain from Times magazine and Scientific America magazine. **Global Perspectives**

• Make predictions on climate change based on published data and global climate models. <u>Liquids</u> • Describe the properties of a liquid on a particulate level. • Use intermolecular forces of attraction to predict the vapor pressure, boiling point and rate of evaporation of different liquids. • Show how a manometer is used to measure vapor pressure. • Show how boiling point is related to external pressure, vapor pressure and temperature. • Describe how hydrogen bonding influences the various properties of water (surface tension, capillary action, heat capacity, viscosity, heat of vaporization and fusion, density). • Review the water cycle and the amount of fresh and salt water are found on Earth. Discuss how man's engineering systems are influencing this ratio. • Interpret vapor pressure curves <u>Solids</u>		• Identify filtration techniques used to purify dirty water around the world. • Compare and contrast the amount of air pollution produced by different countries and determine what actions are being taken to reduce the amount. • Investigate and determine the cause of fish kills that occur in different parts of the country.

● Describe the organization and forces between particles in the solid phase ● Define and give examples of an allotropes. ● Describe the process of melting in terms of potential and kinetic energy. ● Interpret a phase diagram and use it to determine state of matter at a specific temperature and pressure. <u>Aqueous Solutions</u> ● Describe the process by which solutes dissolve in solvents. ● Relate this process to the energetic considerations of the energy of solvation and the dissociation energy. ● Identify the factors that affect the rate of dissolution. ● Use the "like dissolves like" rule to predict the solubility of one substance in another. ● Describe the temperature and pressure effect of gaseous and solid solutes. ● Use solubility curves to answer questions about the saturation level of a solution.		

● Describe solutions as saturated, unsaturated or supersaturated and dilute or concentrated. ● Distinguish between strong electrolytes, weak electrolytes and nonelectrolytes. ● Calculate the concentration of solution. ● Distinguish between a dilute and concentrated solution. Compare the properties of colloids, suspensions and solutions. ● Use Molarity and molality to quantitatively report solution concentration. ● Describe the process of making and aqueous solution from a solid solute. Describe the process of making dilute solutions from a stock solution. Use the dilution equations to calculate the resulting concentration of dilute solutions. ● Describe on a particulate level the effect of dissolved particles on the freezing point, vapor pressure and boiling point of a liquid. ● Calculate the freezing point and boiling point of liquids that containing dissolved particles. ● Use boiling point or freezing point data to determine the molar		

mass of an unknown molecular solute ● Perform stoichiometric calculations using molarity of solutions. ● Show that the concentration of an unknown solution of acid or base can be determined via titration as long as an appropriate indicator is used ● Use the pH scale to classify solutions as acidic, basic or neutral. Determine the pH of a solution from hydrogen ion concentration and vice versa. ● Construct a titration curve for a titration. ● Define a buffer solution and describe the biological significance of these mixtures.		

Modifications: ***Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.(See NGSS Appendix D)***
● *Restructure lesson using UDL principles (*http://www.cast.org/our-work/about-udl.html#.VXmoXcfD_UA*)* ● *Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community.* ● *Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques- auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).*

- *Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tool such as SKYPE, experts from the community helping with a project, journal articles, and biographies).*
- *Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).*
- *Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.*
- *Use project-based science learning to connect science with observable phenomena.*
- *Structure the learning around explaining or solving a social or community-based issue.*
- *Provide ELL students with multiple literacy strategies.*

Leveraging English Language Arts/Literacy and Mathematics

- ***Interdisciplinary Connections***
    - *History: Connect scientific discoveries in various countries to the political and cultural climate in each location*
    - *Mathematics: Statistical analysis of data collected.*
    - *Earth Science: Use radioactive dating to determine the age of the Earth*
- ***Technology Integration***
    - *Use spreadsheet and other analysis tools to examine the relationships of atoms on periodic table*
    - *Use video animations to show setup of historical experiments (Gold foil, Milikan oil drop) Media Literacy Integration*
    - *Use video clips and articles to stimulate interest in the topic eg. Frontline Video: Radioactive Wolves, Fukushima Meltdown*
    - *Compare scientifically reviewed articles (e.g. Nature) to popular literature (e.g. Newsweek) for the same breakthrough. Relate this to the development of atomic theory.*

- ***Global Perspectives***
    - *Discuss the use of nuclear power and other in various countries.*
    - *Global sources of oil, uranium, plutonium*

Samples of Open Education Resources for this unit:

Appendix

Differentiation

Enrichment	● Utilize collaborative media tools ● Provide differentiated feedback ● Opportunities for reflection ● Encourage student voice and input ● Model close reading ● Distinguish long term and short term goals
Intervention & Modification	● Utilize “skeleton notes” where some required information is already filled in for the student ● Provide access to a variety of tools for responses ● Provide opportunities to build familiarity and to practice with multiple media tools ● Leveled text and activities that adapt as students build skills ● Provide multiple means of action and expression ● Consider learning styles and interests ● Provide differentiated mentors ● Graphic organizers
ELLs	● Pre-teach new vocabulary and meaning of symbols ● Embed glossaries or definitions ● Provide translations ● Connect new vocabulary to background knowledge ● Provide flash cards ● Incorporate as many learning senses as possible ● Portray structure, relationships, and associations through concept webs ● Graphic organizers
21st Century Skills	

- Creativity
- Innovation
- Critical Thinking
- Problem Solving
- Communication
- Collaboration

Integrating Technology

- Chromebooks
- Internet research
- Online programs
- Virtual collaboration and projects
- Presentations using presentation hardware and software