MANCHESTER REGIONAL HIGH SCHOOL

Chemistry in the Community
College Prep Chemistry

Adopted June 16, 2016

Manchester Regional High School
District Mission Statement

The mission of Manchester Regional High School is to produce respectful, responsible and well-rounded graduates who possess the knowledge and skills to become contributing members of society and life-long learners.

Highly qualified, collaborative and innovative staff addresses the needs of a diverse school community in a stimulating and nurturing environment.

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TABLE OF CONTENTS

MANCHESTER REGIONAL HIGH SCHOOL

COURSE DESCRIPTION: College Prep Chemistry (Chemistry in the Community)

Chemistry in the Community is a student-centered, activity-based, issues-oriented chemistry course that encourages small group learning. Chemistry in the Community (ChemCom) was developed by the American Chemical Society to improve science literacy through a high school chemistry course that emphasizes chemistry's impact on society. With Chemistry in the Community, students learn concepts on a need-to-know basis, evaluate data, and make decisions based on their knowledge and observations. ChemCom is laboratory-based with activities that give students practice in applying their knowledge of chemistry and meets college standards for science credits. Laboratory investigations are used to introduce and develop important concepts within the context of each unit and are reinforced and extended throughout the spiral design of the course. The units of study cover concepts explained in the context of societal issues, with an emphasis on organic, bio-, environmental and industrial chemistry ChemCom exposes students to the basic concepts of chemistry and helps them to realize the roles that chemistry plays in their lives. It includes many traditional chemistry concepts as well as more biochemistry, industrial, organic and environmental chemistry than is normally encountered in a traditional high school Chemistry course. Students will also demonstrate their learning through creative, multiple modes of expression using various technologies and tools.

COURSE DATA:

Length of course:	Full year
Credits:	Five (Six)
Periods per week:	Five with one double period for lab
Classification:	Grades 10-12
Prerequisite:	College Prep Biology (C or higher), Algerba I (C or higher) and Algebra II (or currently taking)

EVALUATION:

The purposes of evaluation are to provide information about student progress and to determine whether students have learned the subject matter, which has been taught. Teachers will evaluate student progress by utilizing standardized tests, teacher-made quizzes and tests, oral questioning, class participation. Other evaluative criteria will include homework, special projects, special exams and other school records.

NOTE: The following pacing guide was developed during the creation of these curriculum units. The actual implementation of each unit may take more or less time. Time should also be dedicated to preparation for benchmark and State assessments, and analysis of student results on the same. A separate document is included at the end of this curriculum guide with suggestions and resources related to State Assessments (if applicable). The material in this document should be integrated throughout the school year, and with an awareness of the State Testing Schedule. It is highly recommended that teachers meet throughout the school year to coordinate their efforts in implementing the curriculum and preparing students for benchmark and State Assessments in consideration of both the School and District calendars.

Manchester Regional High School Curriculum Guide	
Content Area: Science	
Course Title: College Prep Chemistry (Chemistry in the Community)	**Grade Level: 10-12**

Unit 1 - Materials: Formulating Matter	**9 Weeks**
Unit 2 – Air: Designing Scientific Investigations	**9 Weeks**
Unit 3 - Industry: Applying Chemical Reactions	**9 Weeks**
Unit 4 - Atoms: Nuclear Interactions	**9 Weeks**

Unit 1 Overview – Materials: Formulating Matter	
Stage 1: Desired Results	
Next Generation Science Standards	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties**.[Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]
HS-PS1-3	**Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.** [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]
HS-PS1-7	**Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.**[Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]
HS-PS3-5	**Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.** [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.] [Assessment Boundary: Assessment is limited to systems containing two objects.]
HS-ESS3-2	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.** [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

Unit 1 Overview – Materials: Formulating Matter

Unit Essential Questions

- How do chemists describe matter?
- How does the periodic table help explain and predict the properties of chemical elements?
- What is the role of chemistry in the life cycle of metals?
- How is conservation of matter demonstrated in the use of resources?

Unit Enduring Understandings

- The physical properties of a material can be determined without altering the material's chemical makeup; physical changes alter a material's physical properties. Chemical properties describe how a substance reacts chemically through its transformation into one or more different materials.
- An element is composed of only one type of atom; compounds consist of two or more types of atoms. Both elements and compounds are considered substances.
- A chemical formula indicates the composition of a substance.
- Elements can be classified as metals, nonmetals, or metalloids according to their physical and chemical properties.
- An atom is composed of smaller particles (protons, neutrons, and electrons), each possessing a characteristic mass and electrical charge. The number of protons in an atom of a given element distinguishes it from atoms of all other elements. Atoms containing the same number of protons but different numbers of neutrons are considered isotopes.
- Elements are arranged in the periodic table based on their properties. Elements with similar chemical properties are placed in the same columns. Physical properties vary in predictable patterns across rows and down columns.
- The properties of an element are determined largely by the number and arrangement of electrons in its atoms.
- Ionic compounds are composed of positively and negatively charged ions (atoms that have lost or gained electrons), combined so that the compound has no net electrical charge.
- Tables, graphs, and models are all used to represent scientific data and illustrate scientific ideas so that they are easier to analyze, interpret, and understand.
- Metals react with one another in predictable patterns according to their reactivities.
- The resources for all human activities must be obtained from Earth's atmosphere, hydrosphere, and outer layer of its lithosphere. These resources are not uniformly distributed.
- The feasibility of mining and extracting a mineral resource depends, in part, on how easily a particular metal can be processed and used, which largely depends on its chemical reactivity.
- One mole of substance contains 6.02 x1023 particles. The molar mass of a substance can be calculated from average atomic masses of the component elements.
- The percent composition of a material can be calculated by determining the proportion by mass of each constituent. The percent composition of a substance can be calculated from the relative number of atoms of each element in the substance's formula.
- The processes of oxidation and reduction occur together, resulting in oxidation–reduction (redox) reactions.
- Metal cations can be converted to metal atoms by electrometallurgy, pyrometallurgy,or hydrometallurgy, depending upon the metal's reactivity.
- A chemical equation represents a reaction of one or more substances to form one or more new substances.
- The atoms that compose matter are neither created nor destroyed in a chemical reaction.
- Coefficients in a chemical equation indicate the relative number of units of each reactant and product involved. Subscripts in a substance's formula may not be changed to balance an equation.
- An alloy possesses properties that differ, sometimes significantly, from the properties of its constituent elements.
- Resources are either renewable or nonrenewable. Resources can be conserved by recycling, reducing (controlling rate of use), or replacing them with substitute resources.

Unit 1 Overview – Materials: Formulating Matter

Unit Objective:

The students to consider the sustainability of the bills and coins that they use as currency and to begin to develop a position on the future production and use of United States dollar bills and coins. These topics include matter and its properties; molecular and atomic structure; chemical formulas; nomenclature; ionic bonding; chemical and physical properties and changes; chemical symbols and formulas; periodicity and the periodic table; metal reactivity; oxidation–reduction reactions; conservation of matter and energy; and writing and balancing chemical equations. Students also learn to calculate molar mass and percent composition. Investigations include exploring the properties of metals and nonmetals, comparing metal reactivities, transforming metals into compounds and alloys, separating the metals in a coin, and exploring periodic properties of halogens and halides. The unit culminates with student presentations, in which students make a recommendation about U.S. dollar use, based on scientific data and knowledge of materials properties, and including considerations of responsibility and sustainability.

Content Knowledge:	Skills and Topics
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. (HS-PS1-3) **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) (HS-PS1-7)	**Developing and Using Models** ● Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1) ● Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-5) **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 limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) **Using Mathematics and Computational Thinking** ● Use mathematical representations of phenomena to support claims. (HS-PS1-7) **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, and 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) **Engaging in Argument from Evidence** ● Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations). (HS-ESS3-2) **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)

<table>
<tr><th>Content Knowledge:</th><th>Skills and Topics</th></tr>
<tr><td>PS3.C: Relationship Between Energy and Forces
When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)
ESS3.A: Natural Resources
All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2)
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. (secondary) (HS-ESS3-2)</td><td>Cause and Effect
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-PS3-5)
Energy and Matter
The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)
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)
Science Addresses Questions About the Natural and Material World
Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2)
Science knowledge indicates what can happen in natural systems — not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2)
Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)
Connections to Engineering, Technology, and Applications of Science

Influence of Science, Engineering, and Technology on Society and the Natural World
Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-ESS3-2)
Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)</td></tr>
</table>

<table>
<tr><th colspan="3">STAGE 2: Assessment Evidence</th></tr>
<tr><th>Formative Assessment</th><th colspan="2">Summative Assessment</th></tr>
<tr><td>• Warm-up activities
• Do Now's
• Class discussions
• Student participation
• Teacher observations</td><td colspan="2">• Tests
• Quizzes
• Projects
• Homework
• Lab Reports</td></tr>
<tr><th colspan="3">Laboratory and Exploratory Activities</th></tr>
<tr><td rowspan="3">Exploring Properties of Matter</td><td colspan="2">Practice Standards
HS-PS1-1</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• Paper
• Universal indicator
• NH_3
• CuSO4•5 H2O
• NaHCO3
• NaHCO3, 1 M
• Vinegar
• AgNO3, 0.1 M
• pennies, post-1982
• CuSO4, 1 M
• Watch glass
• Ceramic pad
• Matches
• Test tubes 13 x 100</td><td>• Spatula
• Mortar
• Pestle
• Hot plate
• Crucible
• Glass stirring rod
• Crucible tongs
• Balance
• Tea light
• Well plate, 24-well
• Graduated cylinder, 100 mL
• Density kit
• Iron nails</td></tr>
<tr><td rowspan="3">Metal or Nonmetal</td><td colspan="2">Practice Standards
HS-PS1-1</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• HCl, 0.5 M
• CuCl2, 0.1 M
• C, rod (pencil lead)
• Mg, ribbon
• Si, lumps
• Sn, wire or foil
• S, lump
• Fe, wire</td><td>• Zn, mossy or wire
• Small hammer
• Conductivity apparatue
• Beral pipet
• Well plate-12 wells
• Forceps
• Containers to hold metal samples</td></tr>
</table>

<table>
<tr><th colspan="3">Laboratory and Exploratory Activities</th></tr>
<tr><td rowspan="3">Periodic Trends</td><td colspan="2">Practice Standards
HS-PS1-1</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• chlorine water (Mix 5 mL of 5% NaOCl with 10 mL of 1M HCl, dilute to 30 mL with distilled water)
• NaOCl, 5%
• HCl, 1 M
• bromine water (Mix 10 mL of 1M NaBr and 10 mL of 1M HCl. Add 5 mL 5% NaOCl, dilute to 30 mL with distilled water)</td><td>• iodine water (dissolve 1 g KI in 30 mL H2O, add 0.65 g iodine and mix to dissolve. Dilute to 50 mL with distilled water)
• Hexane
• NaBr, 1 M NaBr, 0.1 M
• NaCl, 0.1 M
• NaI, 0.1 M
• test tube, 13 x 100
• test tube rack
• Beral pipet</td></tr>
<tr><td rowspan="3">Relative Reactivities of Metals</td><td colspan="2">Practice Standards
HS-PS1-2</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• Mg, ribbon
• Zn, wire
• Cu, wire
• Ag, wire or pieces
• Mg(NO3)2, 0.2 M
• Cu(NO3)2, 0.2 M</td><td>• Zn(NO3)2, 0.2 M
• AgNO3, 0.2 M
• dissecting microscope
• well plate, 24-well
• Beral pipet</td></tr>
<tr><td rowspan="3">Extracting Zinc</td><td colspan="2">Practice Standards
HS-PS1-2</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• pennies, post-1982
• HCl, 3.0 M</td><td>• metal file
• balance</td></tr>
<tr><td rowspan="3">Copper Plating</td><td colspan="2">Practice Standards
HS-PS1-1
HS-PS1-2</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• CuCl2, 1 M
• 9-V battery connectors w/alligator clamps
• batteries, 9-V</td><td>• beakers, 250-mL
• U-tubes
• 9 mm mechanical pencil “leads” (graphite electrodes)</td></tr>
</table>

<table>
<tr><th colspan="3">Laboratory and Exploratory Activities</th></tr>
<tr><td rowspan="3">Striking It Rich</td><td colspan="2">Practice Standards
HS-PS1-1</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• Pennies
• Zn, granular
• ZnCl2, 1 M
• H2O, distilled
• steel wool
• beaker, 250-mL
• graduated cylinder, 25-mL</td><td>• crucible tongs
• ring stand
• ring clamp
• wire gauze square
• Bunsen burner or hot plate
• matches</td></tr>
<tr><td rowspan="2">Periodic Variation in Properties</td><td colspan="2">Practice Standards
HS-PS1-3</td></tr>
<tr><td colspan="2">Resources Required
• Graph paper
• Periodic trends information (melting points, boiling points, atomic mass, etc.)</td></tr>
<tr><td rowspan="2">Modeling Matter: Ionic Compounds</td><td colspan="2">Practice Standards
HS-PS3-5</td></tr>
<tr><td colspan="2">Resources Required
• Ion cut outs</td></tr>
<tr><td rowspan="2">Keeping Track of Ions
Accounting for Atoms
Balancing Equations</td><td colspan="2">Practice Standards
HS-PS1-7</td></tr>
<tr><td colspan="2">Resources Required
• Appropriate worksheets</td></tr>
</table>

<table>
<tr><th colspan="2">Stage 3: Learning Plan</th></tr>
<tr><th>21st Century Themes</th><th>21st Century Skills</th></tr>
<tr><td>✓ Global Awareness
✓ Civic Literacy
✓ Financial, Economic, Business, and Entrepreneurial Literacy
✓ Health Literacy</td><td>✓ Creative and Innovation
✓ Information and Communication Technologies Literacy
✓ Media Literacy
✓ Critical Thinking and Problem Solving
✓ Communication and Collaboration
✓ Life and Career Skills
✓ Information Literacy</td></tr>
<tr><th>Integration of Technology</th><th>Suggested Teacher Instructional Resources</th></tr>
<tr><td>● Internet
● Computers
● SMART Boards
● Multimedia presentations
● Video streaming
● Glencoe Virtual Labs</td><td>● Teacher Edition Chemistry in the Community 6th ed
● Teacher’s Resource Manual Chemistry in the Community 6th ed
● http://www.acs.org/content/acs/en.html
● http://hyperphysics.phy-astr.gsu.edu
● http://www.angelo.edu/faculty/kboudrea/demos/calcium_H2O/calcium_H2O.htm
● http://www.coinflation.com/
● www.money.org
● https://www.webelements.com/
● http://www.usmint.gov/
● http://www.moneyfactory.gov/
● http://www.cwsei.ubc.ca/resources/clickers.htm
● http://www.meta-synthesis.com/webbook/35_pt/pt_database.php
● http://www.avogadro.co.uk/definitions/ar.htm
● http://www.rsc.org/errorpage.asp?404;http://www.rsc.org:80/education/teachers/learnnet/periodictable/pre16/develop/index.htm
● http://www.acs.org/content/acs/en/education/whatischemistry/periodictable.html
● https://www.aip.org/history/exhibits/curie/periodic.htm
● http://www.chemheritage.org/discover/online-resources/chemistry-in-history/themes/the-path-to-the-periodic-table/meyer-and-mendeleev.aspx</td></tr>
<tr><td colspan="2">Diverse Learners (ELL, Special Ed, Gifted & Talented)- Differentiation strategies may include, but are not limited to, learning centers and cooperative learning activities in either heterogeneous or homogeneous groups, depending on the learning objectives and the number of students that need further support and scaffolding, versus those that need more challenge and enrichment. Modifications may also be made as they relate to the special needs of students in accordance with their Individualized Education Programs (IEPs) or 504 plans, or English Language Learners (ELL). These may include, but are not limited to, extended time, copies of class notes, refocusing strategies, preferred seating, study guides, and/or suggestions from special education or ELL teachers.</td></tr>
</table>

Unit 2 Overview – Air: Designing Scientific Investigations	
Stage 1: Desired Results	
Next Generation Science Standards	
HS-PS3-1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]
HS-PS3-3	**Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*** [Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency. Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]
HS-PS3-4	**Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).** [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]
HS-PS4-3	**Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.]
HS-PS4-4	**Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.** [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.]

Unit Essential Questions

- What information can investigations provide about gas behavior?
- How are models and theories useful in explaining and predicting behavior of gases?
- What does evidence reveal about properties of Earth's atmosphere?
- How are claims about air quality supported by experimental evidence and chemistry concepts?

Unit Enduring Understandings

- Pressure involves a force applied over a particular area. Air pressure is often expressed in units of atmospheres (atm), kilopascals (kPa), or millimeters of mercury (mmHg).
- The volume of a sample of gas in a flexible, impermeable container will increase if external pressure is reduced, and decrease if external pressure is increased.
- Scientific investigations are conducted for many reasons, including explaining natural phenomena, developing models, and testing hypotheses or claims. Most scientific investigations are based upon a testable scientific question.
- The kinetic molecular theory states that gases are composed of particles of negligible size that are in constant motion and that undergo elastic collisions. The average kinetic energy of a gas sample is directly related to its kelvin temperature.
- For a given gas sample, the ideal gas law expresses the relationship among its volume, pressure, temperature, and amount of gas present.
- Equal numbers of gas molecules at the same temperature and pressure occupy the same total volume. One mole of a gas sample at 0 °C and 1 atm occupies a volume of 22.4 L.
- Scientific theories and models explain observations and data. Scientific laws describe, but do not explain, natural phenomena.
- Under certain conditions, real gases do not behave as predicted by the kinetic molecular theory.
- Temperature is a measure of the average kinetic energy of a sample of matter, while heat is a form of energy that transfers from one "object" to another due to a difference in temperature.
- Transitions among the physical states of a substance, called phase changes, require the addition or release of energy.
- Scientific investigations are designed to produce evidence that will support claims or conclusions, using observations, data, or both.
- The volume of a sample of gas in a flexible, impermeable container at constant pressure will increase if its temperature is increased and decrease if its temperature is decreased.
- The pressure exerted by a sample of gas in a rigid, impermeable container will increase if its temperature is increased, and decrease if its temperature is decreased.
- Earth's atmosphere is composed of a mixture of gases.
- Molecules can break bonds and form new substances when they collide with sufficient energy and suitable orientation.
- The coefficients in a balanced chemical equation that involves gases indicate the relative volumes of gaseous reactants or products.
- Electromagnetic radiation includes X-rays; gamma rays; ultraviolet (UV), visible, and infrared (IR) radiation; radio waves; and microwaves. The energy transmitted by radiation varies according to its wavelength—the shorter the wavelength, the higher the energy.
- Some atmospheric gases, such as carbon dioxide, methane, and water vapor, absorb infrared radiation.
- Earth's atmosphere protects living organisms by absorbing and distributing solar energy.
- Scientific investigations are designed to collect evidence to make and support claims about the natural world.
- Air pollution results from contributions by both primary and secondary pollutants.
- Pollutant concentrations in ambient air are measured using various techniques in order to provide data for air-quality compliance and modeling.
- Photochemical smog can intensify due to temperature inversions and adverse wind patterns.
- Solutions can be characterized as acidic, basic, or chemically neutral on the basis of their observed properties. Water solutions with pH 7.0 at room temperature are neutral; those with lower pH are acidic and those with higher pH are basic.
- Rainwater is naturally acidic, due to dissolved CO2, but contaminants in the atmosphere can produce precipitation that is even more acidic than normal.

● Gaseous sulfur oxides and nitrogen oxides generated from natural and human sources contribute to acid rain. ● Air pollution can be affected by everyday activities and changes in chemical technologies.
Unit Objective:
Unit 2 introduces students to gases, particularly those in Earth's atmosphere, and their physical and chemical properties. Students consider gas behavior on the macroscopic level by exploring changes and relationships among volume, pressure, and temperature. They have opportunities to build connections between their macroscopic observations and the particulate descriptions of gases provided by the kinetic molecular theory (KMT). Key skills for scientific inquiry, such as asking questions as well as making and supporting claims based upon evidence, are also featured in this unit. The organizing issue for this unit is the design of an air-quality investigation. In the culminating activity, students prepare a scientific poster to present their investigation design.

Content Knowledge:	Skills and Topics
PS4.A Wave Properties ● Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) **PS4.B: Electromagnetic Radiation** ● Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) ● 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. (HS-PS4-4) **ESS1.B: Earth and the Solar System** ● Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes.(secondary to HS-ESS2-4)	**Developing and Using Models** ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-6) **Planning and Carrying Out Investigations** ● Analyze data using computational models in order to make valid and reliable scientific claims.(HS-ESS2-6) **Using Mathematics and Computational Thinking** ● Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6) **Constructing Explanations and Designing Solutions** ● Construct 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-PS3-1) **Engaging in Argument from Evidence** ● Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3) **Obtaining, Evaluating, and Communicating Information** ● Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.(HS-PS4-4) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific cause and effect (HS-PS3-1) (HS-ESS2-4) ● 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)

ESS2.A: Earth Materials and System ● The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.(HS-ESS2-4) **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 reradiation into space. (HS-ESS2-4) ● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6) ● Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-6) ● Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary) (HS-ESS3-6) **ESS3.A: Natural Resources** ● Resource availability has guided the development of human society. (HS-PS3-1) **ESS3.B Natural Hazards** ● Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.(HS-PS3-1) **ESS3.D: Global Climate Change** ● Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5)	**Systems and System Models** ● Models (e.g., physical, mathematical, and computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales. (HS-PS4-3) ● When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-SS3-6) ● Energy and Matter ● Models (e.g., physical, mathematical, and computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales. (HS-PS4-3) ● The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) ● Stability and Change ● 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-ESS3-5) ***Connections to Nature of Science*** ● Science Addresses Questions About the Natural and Material World ● Modern civilization depends on major technological systems. (HS-PS3-1) ● Scientific Investigations Use a Variety of Methods ● Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5) ● New technologies advance scientific knowledge. (HS-ESS3-5) **Scientific Knowledge is Based on Empirical Evidence** ● Science knowledge is based on empirical evidence. (HS-ESS3-5) ● Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS3-5) ***Connections to Engineering, Technology, and Applications of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ● A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment. The science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4-3)

STAGE 2: Assessment Evidence		
Formative Assessment	**Summative Assessment**	
• Warm-up activities • Do Now's • Class discussions • Student participation • Teacher observations	• Tests • Quizzes • Projects • Homework • Lab Reports	
Laboratory and Exploratory Activities		
Properties of Gases	**Practice Standards** **HS-PS3-1** **HS-PS4-3**	
	Resources Required	
	• rock salt • Ice • 60-cc syringe with Luer lock cap • balloons, medium or large • beaker tongs • containers for water • Balance • masking tape, roll	• Pin • plastic soft-drink bottle, empty 1- or 2-L • drinking glass • test tube • stiff plastic • plastic wrap, roll • aluminum soft-drink can • hot plate
Exploring Temperature- Volume Relationships	**Practice Standards** **HS-PS3-1**	
	Resources	
	• corn oil • beaker, 600-mL • thermometer readable to 150˚C • capillary melting-point tube (closed one end)	• rubber band (orthodontist type) • paper towels • millimeter ruler • hot plate or small deep-fry applianc
Phase Changes	**Practice Standards** **HS-PS3-4**	
	Resources Required	
	• ice • beaker, 100-mL • beaker tongs • stirring rod	• hot plate • ring stand • Ring • thermometer
Generating and Analyzing CO2	**Practice Standards** **HS-ESS3-6**	
	Resources Required	
	• NaHCO3 • Vinegar • Ca(OH)2 saturated • universal indicator • NaOH, 6M • syringe, 60-cc • Luer lock cap	• vial cap • beaker, 50-mL • latex tubing, 3-mm ID, 12-in piece • stirring rod • birthday candle • matches, book • tape, transparent

<table>
<tr><th colspan="3">Laboratory and Exploratory Activities</th></tr>
<tr><td rowspan="3">Detecting Pollutants in the Air</td><td colspan="2">Practice Standards
HS-ESS3-6</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• Cornstarch
• KI
• Distilled water
• Index cards (3 x 5)
• Paper punch or scissors
• Tape, transparent (wide)
• Microscope
• Beaker 150, mL</td><td>• Stirring rod
• Paint brush, small foam (1-in)
• Hot plate
• Beaker tongs
• Watch glass, large
• Filter paper
• Winre or masking tape
• stopwatch</td></tr>
<tr><td rowspan="3">Effects of Acid Rain</td><td colspan="2">Practice Standards
HS-ESS3-6</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• phenol red
• Na2SO3
• HCl, 1 M
• plant material
• metal sample</td><td>• stone sample
• Dropper bottles
• Spatula
• Petri dish with lid
• forceps</td></tr>
<tr><td rowspan="2">Understanding Kinetic Molecular Theory</td><td colspan="2">Practice Standards
HS-PS3-1</td></tr>
<tr><td colspan="2">Resources Required
• Small boxes (various sizes)
• Super bounce balls</td></tr>
<tr><td rowspan="2">Developing Skills: Solar Radiation</td><td colspan="2">Practice Standards
HS-PS4-3</td></tr>
<tr><td colspan="2">Resources Required
• textbook</td></tr>
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<tr><td>✓ Global Awareness
✓ Civic Literacy
✓ Financial, Economic, Business, and Entrepreneurial Literacy
✓ Health Literacy</td><td>✓ Creative and Innovation
✓ Information and Communication Technologies Literacy
✓ Media Literacy
✓ Critical Thinking and Problem Solving
✓ Communication and Collaboration
✓ Life and Career Skills
✓ Information Literacy</td></tr>
<tr><th>Integration of Technology</th><th>Suggested Teacher Instructional Resources</th></tr>
<tr><td>● Internet
● Computers
● SMART Boards
● Multimedia presentations
● Video streaming
● PhET simulations</td><td>● Teacher Edition Chemistry in the Community 6th ed
● Teacher’s Resource Manual Chemistry in the Community 6th ed
● http://minerals.usgs.gov/minerals/pubs/commodity/nitrogen/mcs-2010-nitro.pdf
● https://www.epa.gov/greenchemistry
● http://www.acs.org/content/acs/en/greenchemistry.html
● http://www.beyondbenign.org/greenchemistry/greenchem.html
● http://www.dtsc.ca.gov/pollutionprevention/greenchemistryinitiative/index.cfm
● http://www.icca-chem.org/en/Home/Responsible-care/
● https://responsiblecare.americanchemistry.com/
● https://www.epa.gov/toxics-release-inventory-tri-program
● http://www.fuelcells.org/</td></tr>
<tr><td colspan="2">Diverse Learners (ELL, Special Ed, Gifted & Talented)- Differentiation strategies may include, but are not limited to, learning centers and cooperative learning activities in either heterogeneous or homogeneous groups, depending on the learning objectives and the number of students that need further support and scaffolding, versus those that need more challenge and enrichment. Modifications may also be made as they relate to the special needs of students in accordance with their Individualized Education Programs (IEPs) or 504 plans, or English Language Learners (ELL). These may include, but are not limited to, extended time, copies of class notes, refocusing strategies, preferred seating, study guides, and/or suggestions from special education or ELL teachers.</td></tr>
</table>

Unit 3 Overview – Industry: Applying Chemical Reactions	
Stage 1: Desired Results	
Next Generation Science Standards	
HS-PS1-1	**Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*]
HS-PS1-2	**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.** [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [*Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.*]
HS-PS1-4	**Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.** [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]
HS-PS1-5	**Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs**. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]
HS-PS1-6	**Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*** [Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]
HS-PS3-1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [*Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.*]

Next Generation Science Standards	
HS-ETS1-1	**Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.** [Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]
HS-ETS1-2	**Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.** [Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]
HS-ETS1-3	**Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.** [Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]
HS-ETS1-4	**Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem** [Clarification Statement: See Three-Dimensional Teaching and Learning Section for examples.]

Unit Essential Questions

- What role does nitrogen chemistry play in agriculture?
- What chemical principles can be used in the responsible manufacture of ammonia?
- How is chemical energy transformed into electrical energy?
- What challenges must be met to optimize production and use of batteries?

Unit Enduring Understandings

- Nitrogen is transformed chemically as it cycles through living systems and the physical environment.
- The tendency of an atom to attract electrons within a covalent chemical bond can be expressed by the electronegativity of that element.
- Assigning oxidation states is a convenient way to identify oxidation or reduction of atoms in reactions.
- The chemical industry transforms elements and compounds into other useful materials.
- The rate of a particular reaction depends on temperature, reactant concentration(s), and the influence of a catalyst.
- When a system is in dynamic equilibrium, the rate of the forward reaction equals, and is thus balanced by, the rate of the reverse reaction.
- Le Châtelier's principle can be used to predict a shift in the equilibrium position of a reversible reaction.
- Ammonia is commonly produced industrially by the Haber–Bosch process.
- Nitrogen compounds are commonly used in explosives.
- Modern management practices in the chemical industry stress conservation, safety, and pollution prevention in decisions about manufacturing, storing, transporting, and disposing of chemical materials.
- Electrochemistry involves chemical changes that produce or are caused by electrical energy.
- The activity series of metals can be used to predict the direction of electron flow within a particular voltaic cell.
- Redox reactions can be used to convert chemical energy to electrical energy by harnessing the flow of electrons.
- Voltaic cells operate spontaneously, leading to constant changes within the system.
- Batteries, which consist of one or more voltaic cells, provide convenient, portable ways to energize many common electrical devices.
- The electrical potential of a voltaic pile or battery depends upon the identity of its electrodes and can be calculated from standard reduction potentials.
- Life cycle analysis of products such as batteries allows designers and users to make informed choices about starting materials, manufacturing, use, and disposal.
- Burden–benefit analysis is useful in weighing both positive and negative consequences when making decisions.

<table>
<tr><th colspan="2">Unit Objective:</th></tr>
<tr><td colspan="2">Industrial chemistry encompasses a wide range of manufacturing processes, including petroleum refining, extracting metals from their ores (addressed in Unit 1), and producing polymers and pharmaceuticals. This unit focuses on the industrial processes associated with producing synthetic inorganic fertilizers and manufacturing lithium-ion batteries.
This unit gives students opportunities to evaluate operations of EKS, a nitrogen products company, and WYE, a battery technology corporation. As students evaluate EKS and WYE, they revisit and expand their previous knowledge of atoms, electrons, ions, electronegativity, oxidation–reduction reactions, activity series, concentration, chemical reactions, and thermochemistry. New concepts introduced in this unit include the nitrogen cycle, oxidation numbers, kinetics, equilibrium, Le Châtelier’s principle, and electrochemistry. Topics directly related to industrial chemistry such as chemical engineering, Green Chemistry, and benefit–burden analysis, are also incorporated.
The unit culminates in a Riverwood Town Council meeting, where students decide whether EKS or WYE (or neither) will be invited to locate in Riverwood in the old Riverwood Corporation building. Their decision will be based on their understanding of the chemistry and risks and benefits involved in operating such large-scale plants.</td></tr>
<tr><th>Content Knowledge:</th><th>Skills and Topics</th></tr>
<tr><td>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-ETS1-1)
● 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-ETS1-1)
● 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)
● 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)
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 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)</td>
<td>Asking Questions and Defining Problems
● Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1)
Developing and Using Models
● Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)
● 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
● Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.
Constructing Explanations and Designing Solutions
● 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-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6)
● Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2)
● Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)
● Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations,</td></tr>
</table>

	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)
Content Knowledge:	**Skills and Topics**
ETS1.A: Defining and Delimiting Engineering Problems ● Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) ● Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **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. **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) (HS-PS1-6) (HS-ETS1-2)	**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-ETS1-1), (HS=PS1-2) (HS-PS1-5) **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. **Energy and Matter** ● 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*** **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)

<table>
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<tr><th>Formative Assessment</th><th colspan="2">Summative Assessment</th></tr>
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• Do Now's
• Class discussions
• Student participation
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• Quizzes
• Projects
• Homework
• Lab Reports</td></tr>
<tr><th colspan="3">Laboratory and Exploratory Activities</th></tr>
<tr><td rowspan="3">Fertilizer Components</td><td colspan="2">Practice Standards
HS-PS1-3</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• litmus paper, red strips
• hydrochloric acid, 2 M
• hydrochloric acid, 6.0 M
• sodium hydroxide, 3 M
• sulfuric acid, 18 M
• sulfuric acid, 6 M
• iron(II) sulfate heptahydrate, 0.1 M
• barium chloride dihydrate, 0.1 M
• potassium thiocyanate, 0.2 M
• sodium phosphate, 0.1 M
• sodium nitrate, 0.1 M
• sodium sulfate decahydrate, 0.1 M
• potassium nitrate, 0.1 M
• ammonium nitrate, 0.1 M</td><td>• iron(III) nitrate, 0.1 M
• distilled water
• unknown solutions, 0.1 M
• beaker, 100-mL
• Bunsen burner
• hot plate
• test tube 18 150 mm
• test tube rack
• test tube holder
• nichrome wire
• cobalt-blue glass squares
• Beral-type pipet, thin-stem
• cassette-tape case</td></tr>
<tr><td rowspan="3">Le Châtelier's Principle</td><td colspan="2">Practice Standards
HS-PS1-6</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• cobalt(II) chloride hexahydrate, 0.1 M tincture
• test tube, 18 150 mm
• ethanol
• test tube holder
• calcium chloride, anhydrous</td><td>• beaker, 400 mL
• silver nitrate, 0.1 M
• hot plate
• sodium chloride
• dropper bottle
• ice</td></tr>
<tr><td rowspan="3">Voltaic Cells</td><td colspan="2">Practice Standards</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>• filter paper
• scissors
• aluminum, plate
• Petri dish
• copper, plate
• voltmeter
• iron, plate
• Beral-type pipets, thin-stem
• magnesium, ribbon
• cassette-tape case
• silver, foil</td><td>• alligator clip with lead
• tin, foil
• zinc, plate
• sodium nitrate, 1.0 M
• aluminum nitrate, 1.0 M
• copper(II) nitrate, 1.0 M
• iron(III) nitrate, 1.0 M
• magnesium nitrate, 1.0 M
• silver nitrate, 1.0 M
• tin(II) chloride, 1.0 M
• zinc nitrate, 1.0 M</td></tr>
</table>

Laboratory and Exploratory Activities	
Building a Voltaic Pile	**Practice Standards**
	Resources Required ● zinc, plates or discs, ~1 cm square ● alligator clip with lead ● Copper, plates or discs, ~1 cm square ● voltmeter ● LED device (e.g., bulb, clock, or thermometer) ● copper sulfate, 1M
School Garden	**Practice Standards**
	Resources Required ●
Modeling Matter “The Nitrogen Cycle”	**Practice Standards**
	Resources Required ● Drawing paper ● Colored pencils/ markers
Developing Skills “Determining Oxidation Numbers”	**Practice Standards** **HS-PS1-1**
	Resources Required ● textbook
	Practice Standards
	Resources Required ●

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<tr><td colspan="2">Diverse Learners (ELL, Special Ed, Gifted & Talented)- Differentiation strategies may include, but are not limited to, learning centers and cooperative learning activities in either heterogeneous or homogeneous groups, depending on the learning objectives and the number of students that need further support and scaffolding, versus those that need more challenge and enrichment. Modifications may also be made as they relate to the special needs of students in accordance with their Individualized Education Programs (IEPs) or 504 plans, or English Language Learners (ELL). These may include, but are not limited to, extended time, copies of class notes, refocusing strategies, preferred seating, study guides, and/or suggestions from special education or ELL teachers.</td></tr>
</table>

Unit 4 Overview – Atoms: Nuclear Processes and Interactions

Stage 1: Desired Results

Next Generation Science Standards

HS-PS1-8 **Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.** [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [*Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.*]

HS-ETS1-2 **Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.**

HS-ETS1-3 **Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.**

Unit Essential Questions

- What evidence led to a modern understanding of the composition of atoms?
- How do we detect and describe the products of nuclear decay?
- Why and how are radioactive isotopes useful?
- What burdens and benefits accompany uses of nuclear energy?

Unit Enduring Understandings

- Radioactive nuclei are unstable and undergo spontaneous changes in their structure.
- Radiation can be classified as either ionizing or non-ionizing, depending on the type of energy it transmits.
- Rutherford's gold-foil experiment results led to a new model of the atom.
- Most elements in nature are a mixture of isotopes. Some isotopes are radioactive.
- A relatively constant level of radioactivity, called background radiation, is always present and contributes to an individual's ionizing-radiation dose.
- Ionizing radiation has sufficient energy to break chemical bonds.
- Alpha, beta, and gamma radiation have different properties that determine their effects on living tissues.
- The emission of nuclear radiation changes the composition of the nucleus.
- Ionizing radiation may be detected by its interaction with matter using a variety of methods.
- Half-life can be defined as the time required for half of the radioactive atoms in a sample to decay.
- Radioisotopes have properties that make them useful as tracers for diagnostic purposes.
- Ionizing radiation emitted by some radioisotopes can be used for medical treatment.
- The conversion (transmutation) of one element to another can be accomplished by the high-energy bombardment of atomic nuclei with subatomic particles or other nuclei.
- Some large nuclei, when bombarded by neutrons, undergo nuclear fission.
- The electricity produced by nuclear power plants originates from the energy released by fission in controlled chain reactions.
- Nuclear fusion is the combination of two relatively small nuclei into a new, more massive nucleus.
- The permanent disposal of radioactive waste poses challenging problems and issues.

Unit Objective:	
This unit confronts one of the most highly charged issues in modern society, the use of nuclear energy and technology. This unit traces the history and development of nuclear energy and technology, from discovery of radioactivity to modern-day reactors and fusion, with emphasis on exploring risks and benefits of nuclear technologies. The facts and principles explored in this unit will, without question, remain applicable to students beyond this course. A major goal of this unit is to provide insight into the nature of atoms by developing facts and principles related to nuclear science and technology. Atomic structure, isotopes, and radiation are revisited and explored in greater detail. The unit introduces radioactivity, radioisotopes, half-life, nuclear transformation, the impact of radiation on human health, and medical applications of nuclear technology. Students use facts and principles explored during the unit to weigh potential benefits of nuclear technology against potential harm it poses to individuals, society, and the environment. Students will also confront and evaluate commonly held misconceptions about nuclear technology. The Putting It All Together activity challenges students to prepare and present information about nuclear science and technology to a senior-citizen group.	
Content Knowledge:	**Skills and Topics**
PS1.C: 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. **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. **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.	**Developing and Using Models** ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8) **Constructing Explanations and Designing Solutions** ● Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-20 ● Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-3). **Energy and Matter** ● In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. ***Connections to Nature 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.

<table>
<tr><th colspan="3">STAGE 2: Assessment Evidence</th></tr>
<tr><th>Formative Assessment</th><th colspan="2">Summative Assessment</th></tr>
<tr><td>Warm-up activities
Do Now’s
Class discussions
Student participation
Teacher observations</td><td colspan="2">Tests
Quizzes
Projects
Homework
Lab Reports</td></tr>
<tr><th colspan="3">Laboratory and Exploratory Activities</th></tr>
<tr><td rowspan="3">Fertilizer Components</td><td colspan="2">Practice Standards</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>Litmus paper, red strips
Hydrochloric acid, 2M
Hydrochloric acid 6.0 M
Sodium hydroxide 3M
Sulfuric acid 18 M
Iron (II) sulfate heptahydrate, 0.1 M
Potassium thiocyanate 0.2 M
Sodium phosphate 0.1 M
Sodium nitrate 0.1 M
Sodium sulfate decahydrate 0.1 M
Potassium nitrate, 0.1 M
Iron (III) nitrate, 0.1 M Distilled water</td><td>Unknown solutions
Beaker, 100 mL
Bunsen burner
Hot plate
Test tubes 18 x 150mm
Test tube rack
Test tube holder
Cobalt-blue glass squares
Beral-type pipet, thin-stem
Cassette tape case</td></tr>
<tr><td rowspan="3">Le Châtelier’s Principle</td><td colspan="2">Practice Standards</td></tr>
<tr><td colspan="2">Resources Required</td></tr>
<tr><td>Cobalt (II) chloride hexahydrate, 0.1 M tincture
Ethanol
Calcium chloride, anhydrous
Silver nitrate 0.1 M
Sodium chloride</td><td>Ice
Test tube 18 x 150 mm
Test tube holder
Beaker 400 mL
Hot plate
Dropper bottle</td></tr>
</table>

Stage 3: Learning Plan	
21st Century Themes	**21st Century Skills**
✓ Global Awareness ✓ Civic Literacy ✓ Financial, Economic, Business, and Entrepreneurial Literacy ✓ Health Literacy	✓ Creative and Innovation ✓ Information and Communication Technologies Literacy ✓ Media Literacy ✓ Critical Thinking and Problem Solving ✓ Communication and Collaboration ✓ Life and Career Skills ✓ Information Literacy
Integration of Technology	**Suggested Teacher Instructional Resources**
● Internet ● Computers ● SMART Boards ● Multimedia presentations ● Video streaming ● Glencoe Virtual Labs	● Teacher Edition Chemistry in the Community 6th ed ● Teacher's Resource Manual Chemistry in the Community 6th ed
Diverse Learners (ELL, Special Ed, Gifted & Talented)- Differentiation strategies may include, but are not limited to, learning centers and cooperative learning activities in either heterogeneous or homogeneous groups, depending on the learning objectives and the number of students that need further support and scaffolding, versus those that need more challenge and enrichment. Modifications may also be made as they relate to the special needs of students in accordance with their Individualized Education Programs (IEPs) or 504 plans, or English Language Learners (ELL). These may include, but are not limited to, extended time, copies of class notes, refocusing strategies, preferred seating, study guides, and/or suggestions from special education or ELL teachers.	