# Plainfield Public School District Science Curriculum: High School Chemistry

# Next Generation Science Standards

In 2009, a Carnegie Foundation commission of distinguished researchers and public and private leaders concluded that "the nation's capacity to innovate for economic growth and the ability of American workers to thrive in the modern workforce depend on a broad foundation of math and science learning, as do our hopes for preserving a vibrant democracy and the promise of social mobility that lie at the heart of the American dream"[1]. However, the U.S. system of science and mathematics education is performing far below par and, if left unattended, will leave millions of young Americans unprepared to succeed in a global economy.

**Reduction of the United States' competitive economic edge**

- **Shrinking share of patents**: Foreign competitors filed over half of U.S. technology patent applications in 2010[2].
- **Diminishing share of high-tech exports**: Our share of high-tech exports in on the decline, while China has become the single largest exporting country for high-tech products. Correspondingly, the United States' high-tech trade deficit continues to grow[3].

**Essential preparation for all careers in the modern workforce**

- When we think science education, we tend to think preparation for careers in science, technology, engineering and mathematics, which are wellsprings of innovation in our economy. Why then is ensuring scientific and technological literacy for all students of equal concern? Over the past decades, demands have shifted in favor of skilled jobs requiring more education than the unskilled jobs they replaced. Moreover, many of the fastest growing occupations are those where science and mathematics play a central role.

- The National Association of State Directors of Career Technical Education Consortium, grouped all occupations into 16 career clusters[8]. Fourteen of the 16 career clusters call for four years of science, with the remaining two clusters calling for three years. All 16 called for four years of mathematics. The inescapable message: to keep their options open and maximize their opportunities, all students should follow a rigorous program in both science and mathematics.

**Scientific and technological literacy for an educated society**

- Beyond the concern of employability looms the larger question of what it takes to thrive in today's society. Citizens now face problems from pandemics to energy shortages whose solutions require all the scientific and technological genius we can muster. Americans are being forced to increasingly make decisions—including on health care and retirement planning—where literacy in science and mathematics is a real advantage. Contrast these demands with the results of the 2003 National Assessment of Adult Literacy. Fewer than one in three *college graduates* can perform tasks such as interpreting a data table about blood pressure and physical activity[9].

For additional information go to: http://www.nextgenscience.org/

# NJ Model Curriculum: Science-Chemistry

The purpose of providing a "model" is to assist districts and schools with implementation of the Common Core State Standards and New Jersey Core Curriculum Content Standards by providing an example from which to work and/or a product for implementation. Each unit contains targeted student learning objectives (SLOs) that elucidate what students need to know and be able to do within the unit. The six-week formative assessments included in the model curriculum help clarify the level of rigor expected from the standards and provide a set of assessment tools that are often difficult for districts and schools to create on their own.

The model curriculum provides a framework for the development of a more detailed local curriculum. The courses and units were developed through the work of consortia of practicing teachers, science supervisors, and higher education faculty. Each unit of instruction includes a guiding question, a unit overview, estimated number of instructional days necessary to complete the unit, and Student Learning Objectives. The educators who developed the second edition of the model science curriculum included the following sections to assist others in transforming their classrooms to meet or exceed the demands of the new science standards.

For additional information go to: [http://www.nj.gov/education/modelcurriculum/sci/chem.shtml](http://www.nj.gov/education/modelcurriculum/sci/chem.shtml)

CHEMISTRY

Scope and Sequence

| Marking Period 1 | |
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| Big Idea: Laboratory Safety<br><br>Students learn about laboratory safety and the basic laboratory skills necessary to prevent accidents. | Big Idea: The Periodic Table<br><br>Students 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. |
| Big Idea: Chemical Reactions<br><br>Students 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. | |

| **Marking Period 2** | |
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| Big Idea: Strength of Intramolecular and Intermolecular Forces<br><br>Students 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. | Big Idea: Molecular Level Effects on Macro Level Properties & Tradeoffs in Designed Materials<br><br>1.) Students communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.<br>2.) Students 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. |
| Big Idea: Thermodynamics and Water<br><br>1.) Students 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 | Big Idea: Salt Mining<br><br>1.) Students evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. |

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| among the components in the system (second law of thermodynamics).<br>2.) Students plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. | 2.) Students evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. |

| **Midterm Exam** |
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| Big Idea: Design a Solution to Make the Production or Use of Rock Salt More Efficient<br><br>1.) Students analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.<br>2.) Students design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.<br>3.) Students 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. |

| **Marking Period 3** | |
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| Big Idea: Stoichiometry<br><br>Students use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. | Big Idea: Thermal Chemistry<br><br>Students 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. |

| **Marking Period 4** | |
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| Big Idea: Reaction Rates and Equilibrium<br><br>1.) Students 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. | Big Idea: Photosynthesis and Respiration<br><br>**1.)** Students use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new |

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| 2.) Students refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium. | compounds are formed resulting in a net transfer of energy.<br>**2.)** Students construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules.<br>**3.)** Students use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. |

<table>
<tr><td rowspan="4">Time/<br>Terms<br><br>Sept – week 1,2<br><br>MP 1</td><td colspan="3">Big Idea: Safety in the Chemistry Laboratory</td></tr>
<tr><td colspan="3">Topic(s): Laboratory and Chemical Safety</td></tr>
<tr><td colspan="3">Goals: The student will be able to describe and practice proper laboratory behavior.</td></tr>
<tr><td>Standards/Concepts /CPI<br>Students will be able to:</td><td>Essential Questions/Enduring Understanding</td><td>Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources</td></tr>
<tr><td></td><td>Describe and practice proper laboratory behavior.</td><td>Essential Questions:<br><br>Why is following the safety rules the responsibility of everyone?<br><br>Enduring Understandings:<br><br>Scientific safety involves being aware of what to do and what not to do to ensure the safety of one’s self and others in the science laboratory,</td><td>Objectives:<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>- identify and practice proper laboratory behavior with 90% proficiency on a test.<br><br>Activities/ Procedures<br><br>By way of Flinn’s Safety Rules, the Learner will:<br><br>• Identify important laboratory behavior.<br>• Identify, locate, and know how to use laboratory safety equipment.<br>• Demonstrate safe laboratory practices, procedures, and techniques.<br><br>Assessments<br><br>Flinn Safety Test found at http://www.flinnsci.com/teacher-resources/safety/safety-contracts-and-safety-exams.aspx<br><br>Follow-up/extension<br><br>• Observe students locating, identifying, and using safety equipment and practices in the lab.</td></tr>
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| | | | • Have students respond to questions such as: "What should you do first if your lab partner spills hydrochloric acid?"<br><br>Have each student make a safety-related poster that focuses on one of the main safety topics, such as the use of goggles during a lab. The poster should include the rule and a visual depiction of the rule, such as a cartoon, sketch, or photograph.<br><br>**Additional Resources/ Materials**<br><br>PowerPoint presentation on lab safety.<br>http://www.chem.unl.edu/safety/hslabcon.html.<br><br>*Safety in Science Teaching. NSTA SciLinks* |

| Time/ Terms<br><br>MP 1 | Big Idea: The Periodic Table | | |
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| | Topic(s): Organizing the Elements; Classifying; Periodic Trends | | |
| | Goals: 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.] | | |
| | **Standards/Concepts/ CPI**<br>**Students will be able to:** | **Essential Questions/Enduring Understanding** | **Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources** |
| | **HS-PS1-1**<br>**Scientific and Engineering Practices**<br>***Developing and Using Models***<br>• Use a model to | **Essential Questions:**<br><br>How can a periodic table tell me about the subatomic structure of a substance?<br><br>**Enduring Understandings:**<br><br>• Different patterns may be observed | **Objectives**<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>1. Components of the model:<br>a.) From the given model, students identify and describe the components of the model that are |

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| | predict the relationships between systems or between components of a system.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***PS1.A: Structure and Properties of Matter***<br>• Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.<br>• 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.<br><br>**<u>Cross Cutting Concepts</u>**<br>***Patterns***<br>• Different | at each of the scales at which a system is studied, and these patterns can provide evidence for causality in explanations of phenomena.<br>• Each atom has a charged substructure. • An atom's nucleus is made of protons and neutrons and is surrounded by electrons.<br>• The periodic table orders elements horizontally by number of protons in the nucleus of each element's atoms and places elements with similar chemical properties in columns.<br>• The repeating patterns of this table reflect patterns of outer electron states.<br>• Patterns of electrons in the outermost energy level of atoms can provide evidence for the relative properties of elements at different scales.<br>• 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. | relevant for their predictions, including:<br>(i.) Elements and their arrangement in the periodic table;<br>(ii.) A positively-charged nucleus composed of both protons and neutrons, surrounded by negatively-charged electrons;<br>(iii.) Electrons in the outermost energy level of atoms (i.e., valence electrons); and (iv.) The number of protons in each element.<br><br>2. Relationships<br>a.) Students identify and describe the following relationships between components in the given model, including:<br>(i.)The arrangement of the main groups of the periodic table reflects the patterns of outermost electrons.<br>(ii.) Elements in the periodic table are arranged by the numbers of protons in atoms.<br><br>3. Connections<br>a.) Students use the periodic table to predict the patterns of behavior of the elements based on the attraction and repulsion between electrically charged particles and the patterns of outermost electrons that determine the typical reactivity of an atom.<br>b.) Students predict the following patterns of properties:<br>(i.) The number and types of bonds formed (i.e. ionic, covalent, metallic) by an element and between elements;<br>(ii.) The number and charges in stable ions that form from atoms in a group of the periodic<br><br>**Activities/ Procedures**<br><br>The student will use reading assignments, hands-on investigations, problem solving activities, scientific explanations, and scientific reasoning to master the following: |

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| | 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. | | • Read and interpret the periodic table<br>• Explain the properties of elements based on their placement within the periodic table<br>• Name many elements, their atomic number, and other properties<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>“Do Now’s” to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Textbook Resources:<br>Prentice Hall Chemistry chapter 6<br>Laboratory Manual<br>Core Teaching Resources<br>Small Scale Lab Manual<br>ExamView Pro Test Maker<br>Enrichment: Concept challenge activities |

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| | | | Remediation /Instructional Adjustments:<br>Modifications, student difficulties, possible misunderstandings<br>Reading Study Guide<br>CPO Atom Building Game Board<br>Kahn Academy<br>PBS Hunting the elements |

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| Time/ Terms<br><br>MP 1 | Big Idea: Chemical Reactions | | |
| | Topic(s): Describing Chemical Reactions; Electronegativity, Ionization Energy, Scientific Explanations | | |
| | Goals: 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. | | |
| | **Standards/Concepts/ CPI<br>Students will be able to:** | **Essential Questions/Enduring Understanding** | **Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources** |
| | <br>**<u>Science and Engineering Practices</u>**<br>***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 | **Essential Questions:**<br><br>How can I use the periodic table to predict if I need to duck before mixing two elements?<br><br>**Enduring Understandings:**<br><br>Chemical reactions are predictable by elements electronegativity, ionization energy, and Octet Rule.<br><br>A chemical reaction is a process in which one or more substances are converted into new substances having different chemical and physical properties.<br><br>The reactants are substances that change by entering into a chemical reaction; this result in formation of products, the new | **Objectives:**<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>1 Articulating the explanation of phenomena a Students construct an explanation of the outcome of the given reaction, including:<br>i. The idea that the total number of atoms of each element in the reactant and products is the same;<br>ii. The numbers and types of bonds (i.e., ionic, covalent) that each atom forms, as determined by the outermost (valence) electron states and the electronegativity;<br>iii. The outermost (valence) electron state of the atoms that make up both the reactants and the products of the |

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| | scientific ideas, principles, and theories.<br>• 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.<br>**Disciplinary Core Ideas**<br>***PS1.A: Structure and Properties of Matter***<br>• 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. | substances formed.<br><br>The Octet Rule, and the role of valence electrons, helps chemists understand why some reactions occur but others do not.<br><br>Formula equations, which contain all of the correct formulas of the substances involved, are shorthand ways to represent chemical reactions; chemists use symbols to represent elements and words (plus, yields, solids, etc.).<br><br>Experiments have demonstrated that matter is not gained or lost during chemical reactions (Law of Conservation of Mass), so chemical equations must be balanced to reflect this fact. Coefficients are written before formulas to balance chemical equations. (Subscripts of correctly-written formulas must not be changed!)<br><br>Balancing of chemical equations is essential for further study, and it is generally done by trial-and-error or simple inspection.<br><br>Over many years, chemists have come to recognized that there are only a few basic types of chemical reactions: Synthesis (direct combination), Decomposition (breaking a compounds into components), Single Replacement (one element for another), Double Replacement (ionic compounds swapping anions and cations), Combustion (burning a fuel in air or oxygen) and REDOX (oxidation/reduction, where electrons are lost by one atom and gained by another). (Note that there is some overlap | reaction is based on their position in the periodic table; and<br>iv. A discussion of how the patterns of attraction allow the prediction of the type of reaction that occurs (e.g., formation of ionic compounds, combustion of hydrocarbons).<br>2 Evidence a Students identify and describe the evidence to construct the explanation, including:<br>i. Identification of the products and reactants, including their chemical formulas and the arrangement of their outermost (valence) electrons;<br>ii. Identification that the number and types of atoms are the same both before and after a reaction;<br>iii. Identification of the numbers and types of bonds (i.e., ionic, covalent) in both the reactants and the products;<br>iv. The patterns of reactivity (e.g., the high reactivity of alkali metals) at the macroscopic January 2015 Page 1 of 2 level as determined by using the periodic table; and<br>v. The outermost (valence) electron configuration and the relative electronegativity of the atoms that make up both the reactants and the products of the reaction based on their position in the periodic table.<br>3 Reasoning<br>a. Students describe their reasoning that connects the evidence, along with the assumption that theories and laws that describe their natural world operate today as they did in the past and will continue to do so in the future, to construct an explanation for how the patterns of outermost electrons and the electronegativity of elements can be used to predict the number and types of bonds each |

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| | ***PS1.B: Chemical Reactions***<br>• 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.<br>**<u>Crosscutting Concepts</u>**<br>**<u>Patterns</u>**<br>• 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. | in these classifications.) | element forms.<br>b. In the explanation, students describe the causal relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity.<br>4 Revising the explanation<br>a. Given new evidence or context, students construct a revised or expanded explanation about the outcome of a chemical reaction and justify the revision.<br><br>**Activities/ Procedures:**<br><br>The student will use hands-on investigations, problem solving activities, scientific communication, and scientific reasoning to master the following:<br><br>• Predict the products of chemical reactions given the reactants and electronegativity of elements.<br>• Write scientific explanations using evidence from laboratory reports.<br>• Revise scientific explanations in light of new information or evidence.<br>• Write a balanced chemical equation<br>• Investigation: Reactivity of Halogens<br>• Investigation: Reactivity of Metals<br>• Investigation: Law of conservation of mass<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher. |

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| | | | Icebreaker activity to assess knowledge of topic(s) covered.<br><br>“Do Nows” to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Textbook Resources:<br>Prentice Hall Chemistry chapter 11<br>Laboratory Manual<br>Core Teaching Resources<br>Small Scale Lab Manual<br>ExamView Pro Test Maker<br>Enrichment: concept challenge activities<br>Remediation/Instructional Adjustments: Modifications, student difficulties, possible misunderstandings<br>Reading Study Guide<br>PhET Simulations<br>Kahn Academy |

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| Time/ Terms<br><br>MP 2 | Big Idea: Strength of Intramolecular and Intermolecular Forces |
| | Topic(s): Ionic Bonds; Covalent Bonds; Dipole-dipole Forces; Dispersion Forces |

| | Goals: 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. Emphasis is on students 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.] | | |
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| | **Standards/Concepts/ CPI<br>Students will be able to:** | **Essential Questions/Enduring Understanding** | **Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources** |
| | **<u>Science and Engineering Practices</u>**<br>***Planning and Carrying Out Investigations***<br>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.<br>• 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 | **Essential Questions:**<br>How can I use the properties of something (in bulk quantities) to predict what is happening with the subatomic particles?<br><br>**Enduring Understandings:**<br>• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.<br>• 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.<br>• 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. | **Objectives:**<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>1 Identifying the phenomenon to be investigated<br>a. Students describe the phenomenon under investigation, which includes the following idea: the relationship between the measurable properties (e.g., melting point, boiling point, vapor pressure, surface tension) of a substance and the strength of the electrical forces between the particles of the substance.<br>2 Identifying the evidence to answer this question<br>a. Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data, including bulk properties of a substance (e.g., melting point and boiling point, volatility, surface tension) that would allow inferences to be made about the strength of electrical forces between particles.<br>b. Students describe why the data about bulk properties would provide information about strength of the electrical forces between the particles of the chosen substances, including the following descriptions:<br>i. The spacing of the particles of the chosen substances can change as a result of the experimental procedure even if the |

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| | the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.<br>**<u>Disciplinary Core Ideas</u>**<br>***PS1.A: Structure and Properties of Matter***<br>• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.<br>**<u>Crosscutting Concepts</u>**<br>***Patterns***<br>• 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. | | identity of the particles does not change (e.g., when water is boiled the molecules are still present but further apart).<br>ii. Thermal (kinetic) energy has an effect on the ability of the electrical attraction between particles to keep the particles close together. Thus, as more energy is added to the system, the forces of attraction between the particles can no longer keep the particles close together.<br>iii. The patterns of interactions between particles at the molecular scale are reflected in the January 2015 Page 1 of 2 patterns of behavior at the macroscopic scale.<br>iv. Together, patterns observed at multiple scales can provide evidence of the causal relationships between the strength of the electrical forces between particles and the structure of substances at the bulk scale.<br>3 Planning for the investigation<br>a. In the investigation plan, students include:<br>i. A rationale for the choice of substances to compare and a description of the composition of those substances at the atomic molecular scale.<br>ii. A description of how the data will be collected, the number of trials, and the experimental set up and equipment required.<br>b. Students describe how the data will be collected, the number of trials, the experimental set up, and the equipment required.<br>4 Collecting the data<br>a. Students collect and record data — quantitative and/or qualitative — on the bulk properties of substances.<br>5 Refining the design |

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| | | | a. Students evaluate their investigation, including evaluation of:<br>i. Assessing the accuracy and precision of the data collected, as well as the limitations of the investigation; and<br>ii. The ability of the data to provide the evidence required.<br>b. If necessary, students refine the plan to produce more accurate, precise, and useful data<br><br>**Activities/ Procedures**<br><br>The student will use hands-on investigations, problem solving activities, scientific communication, and scientific reasoning to master the following:<br><br>• Distinguish the relative strengths of intramolecular and intermolecular forces.<br>• Plan and conduct a scientific experiment.<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>"Do Nows" to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources. |

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| | | | Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Textbook Resources:<br>Prentice Hall Chemistry chapter 14<br>Laboratory Manual<br>Core Teaching Resources<br>Small Scale Lab Manual<br>ExamView Pro Test Maker<br>Enrichment: concept challenge activities<br>Remediation/Instructional Adjustments:<br>Modifications, student difficulties, possible misunderstandings<br>Reading Study Guide<br>USGS Water Properties Website |

| Time/ Terms<br><br>MP 2 | **Big Idea:** Molecular Level Effects on Macro Level Properties & Tradeoffs in Designed Materials |
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| | **Topic(s)**: Communicating Scientific and Technical Information; Evaluating Designed Solutions; |
| | **Goals:**<br>1.) Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. Emphasis is on students understanding the attractive and repulsive forces that determine the functioning of the material.<br>2.) 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. |

| | Standards/Concepts/ CPI<br>Students will be able to: | Essential Questions/Enduring Understanding | Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources |
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| | **HS-PS2-6**<br>**<u>Science and Engineering Practices</u>**<br>***Obtaining, Evaluating, and Communicating Information***<br>Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs<br>• 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 oral, graphical, textual and mathematical).<br><br>**<u>Disciplinary Core Ideas</u>**<br>***PS2.B: Types of*** | **Essential Questions:**<br><br>What is the greener choice rock salt or calcium chloride for deicing roads and sidewalks?<br><br>**Enduring Understandings:**<br><br>• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.<br>• 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.<br>• When evaluating solutions, it is important to take into account a range of Students who understand the concepts are able to:<br>• Communicate scientific and technical information about why the molecular -level structure is important in the functioning of designed materials.<br>• Evaluate a solution to a complex real-world problem based on constraints, including cost, safety, reliability, aesthetics, and to consider social, cultural, and environmental impacts.<br>• 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 | **Objectives**<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>1 Communication style and format<br>a. Students use at least two different formats (including oral, graphical, textual and mathematical) to communicate scientific and technical information, including fully describing the structure, properties, and design of the chosen material(s). Students cite the origin of the information as appropriate.<br>2 Connecting the DCIs and the CCCs<br>a. Students identify and communicate the evidence for why molecular level structure is important in the functioning of designed materials, including:<br>i. How the structure and properties of matter and the types of interactions of matter at the atomic scale determine the function of the chosen designed material(s); and<br>ii. How the material's properties make it suitable for use in its designed function.<br>b. Students explicitly identify the molecular structure of the chosen designed material(s) (using a representation appropriate to the specific type of communication — e.g., geometric shapes for drugs and receptors, ball and stick models for long-chained molecules).<br>c. Students describe the intended function of the chosen designed material(s).<br>d. Students describe the relationship between the material's function and its macroscopic |

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| | ***Interactions***<br>• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.<br><br>**<u>Crosscutting Concepts</u>**<br>***Structure and Function***<br>• 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.<br><br>**HS-ETS1-3.**<br>**<u>Science and Engineering Practices</u>**<br>***Constructing Explanations and Designing Solutions***<br>Constructing explanations and designing solutions in | 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. • Models (e.g., physical, mathematical, computer models) can be used to simulate why the molecular-level structure is important in the functioning of designed materials. | properties (e.g., material strength, conductivity, reactivity, state of matter, durability) and each of the following:<br>i. Molecular level structure of the material;<br>ii. Intermolecular forces and polarity of molecules; and<br>iii. The ability of electrons to move relatively freely in metals.<br>e. Students describe the effects that attractive and repulsive electrical forces between molecules have on the arrangement (structure) of the chosen designed material(s) of molecules (e.g., solids, liquids, gases, network solid, polymers).<br>f. Students describe that, for all materials, electrostatic forces on the atomic and molecular scale results in contact forces (e.g., friction, normal forces, stickiness) on the macroscopic scale.<br><br>**HS-ETS1-3.**<br>1 Evaluating potential solutions a In their evaluation of<br>a. complex real-world problem, students:<br>i. Generate a list of three or more realistic criteria and two or more constraints, including such relevant factors as cost, safety, reliability, and aesthetics that specifies an acceptable solution to a complex real-world problem;<br>ii. Assign priorities for each criterion and constraint that allows for a logical and systematic evaluation of alternative solution proposals;<br>iii. Analyze (quantitatively where appropriate) and describe the strengths and weaknesses of the solution with respect to each criterion and constraint, as well as social and cultural acceptability |

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| | 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.<br>• Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***ETS1.B: Developing Possible Solutions***<br>• 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. | | and environmental impacts;<br>iv. Describe possible barriers to implementing each solution, such as cultural, economic, or other sources of resistance to potential solutions; and<br>v. Provide an evidence-based decision of which solution is optimum, based on prioritized criteria, analysis of the strengths and weaknesses (costs and benefits) of each solution, and barriers to be overcome.<br>2 Refining and/or optimizing the design solution<br>a. In their evaluation, students describe which parts of the complex real-world problem may remain even if the proposed solution is implemented.<br><br>**HS-ETS1-4.**<br>1 Representation<br>a. Students identify the following components from a given computer simulation:<br>i. The complex real-world problem with numerous criteria and constraints;<br>ii. The system that is being modeled by the computational simulation, including the boundaries of the systems;<br>iii. What variables can be changed by the user to evaluate the proposed solutions, tradeoffs, or other decisions; and<br>iv. The scientific principle(s) and/or relationship(s) being used by the model.<br>2 Computational Modeling<br>a. Students use the given computer simulation to model the proposed solutions by:<br>i. Selecting logical and realistic inputs; and<br>ii. Using the model to simulate the effects of different solutions, tradeoffs, or other decisions.<br>3 Analysis |

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| | **<u>Crosscutting Concepts</u>**<br>***Connections to Engineering, Technology, and Applications of Science Influence of Science, Engineering, and Technology on Society and the Natural World***<br>• 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.<br><br>**HS-ETS1-4**<br>**<u>Science and Engineering Practices</u>**<br>***Using Mathematics and Computational Thinking***<br>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 | | a. Students compare the simulated results to the expected results.<br>b. Students interpret the results of the simulation and predict the effects of the proposed solutions within and between systems relevant to the problem based on the interpretation.<br>c. Students identify the possible negative consequences of solutions that outweigh their benefits.<br>d. Students identify the simulation's limitations.<br><br>**Activities/ Procedures**<br><br>By way of embedded reading support, prior knowledge, and adapted graphic organizers the Learner will:<br>Write a Scientific Argument:<br>• Identifying the greener choice of deicing solutions.<br>• Explaining molecular level descriptions of the functioning deicing solutions.<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>"Do Nows" to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources. |

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| | 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.<br>• Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***ETS1.B: Developing Possible Solutions***<br>• 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 | | Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>**Additional Resources/ Materials**<br><br>Internet Resources<br>Teacher Made Graphic Organizers |

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| | most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.<br><br>**Crosscutting Concepts**<br>***Systems and System Models***<br>• 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. | | |

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| Time/ Terms<br><br>MP 2 | **Big Idea:** Thermodynamics and Water |
| | **Topic(s):** Thermodynamics; Properties of Water |
| | **Goals:**<br>3.) 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).<br>4.) Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. |

| | Standards/Concepts/ CPI<br>Students will be able to: | Essential Questions/Enduring Understanding | Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources |
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| | **HS-PS3-2**<br>**<u>Science and Engineering Practices</u>**<br>***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.<br>• Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***PS3.A: Definitions of Energy***<br>• Energy is a quantitative property of a system that depends on the motion and interactions of | **Essential Questions:**<br><br>Does thermal energy always transfer or transform in predictable ways?<br><br>What makes water's properties essential to life on our planet? or Why do we look for water on other planets? or What makes water so special?<br><br>**Enduring Understandings:**<br><br>• 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.<br>• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.<br>• Uncontrolled systems always move toward more stable states—that is, toward a more uniform energy distribution.<br>• Although energy cannot be destroyed, it can be converted into less useful forms—for example, to thermal energy in the surrounding environment.<br>• 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.<br>• The functions and properties of water and water systems can be inferred from | **Objectives**<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>1 Components of the model<br>a. Students develop models in which they identify and describe the relevant components, including:<br>i. All the components of the system and the surroundings, as well as energy flows between the system and the surroundings;<br>ii. Clearly depicting both a macroscopic and a molecular/atomic-level representation of the system; and<br>iii. Depicting the forms in which energy is manifested at two different scales:<br>a) Macroscopic , such as motion, sound, light, thermal energy, potential energy or energy in fields; and<br>b) Molecular/atomic, such as motions (kinetic energy) of particles (e.g., nuclei and electrons), the relative positions of particles in fields (potential energy), and energy in fields.<br>2 Relationships<br>a. Students describe the relationships between components in their models, including:<br>i. Changes in the relative position of objects in gravitational, magnetic or electrostatic fields can affect the energy of the fields (e.g., charged objects moving away from each other change the field energy).<br>ii. Thermal energy includes both the kinetic |

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| | 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.<br>• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.<br>• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the | the overall structure, the way the components are shaped and used, and the molecular substructure.<br>• 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. | and potential energy of particle vibrations in solids or molecules and the kinetic energy of freely moving particles (e.g., inert gas atoms, molecules) in liquids and gases.<br>iii. The total energy of the system and surroundings is conserved at a macroscopic and molecular/atomic level.<br>iv. Chemical energy can be considered in terms of systems of nuclei and electrons in electrostatic fields (bonds).<br>v. As one form of energy increases, others must decrease by the same amount as energy is transferred among and between objects and fields.<br>3 Connections<br>a. Students use their models to show that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is transferred into or out of the system.<br>b. Students use their models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects on both the macroscopic and microscopic scales.<br>1 Identifying the phenomenon to be investigated<br>a. Students describe the phenomenon under investigation, which includes the following idea: a connection between the properties of water and its effects on Earth materials and surface processes.<br>2 Identifying the evidence to answer this question<br>a. Students develop an investigation plan and |

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| | relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.<br><br>**<u>Crosscutting Concepts</u>**<br>***Energy and Matter***<br>• Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.<br><br>**HS-ESS2-5**<br><br>**<u>Science and Engineering Practices</u>**<br>***Planning and Carrying Out Investigations***<br>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, | | describe the data that will be collected and the evidence to be derived from the data, including:<br>i. Properties of water, including:<br>a) The heat capacity of water;<br>b) The density of water in its solid and liquid states; and<br>c) The polar nature of the water molecule due to its molecular structure.<br>ii. The effect of the properties of water on energy transfer that causes the patterns of temperature, the movement of air, and the movement and availability of water at Earth's surface.<br>iii. Mechanical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include:<br>a) Stream transportation and deposition using a stream table, which can be used to infer the ability of water to transport and deposit materials;<br>b) Erosion using variations in soil moisture content, which can be used to infer the ability of water to prevent or facilitate movement of Earth materials; and<br>c) The expansion of water as it freezes, which can be used to infer the ability of water to break rocks into smaller pieces.<br>iv. Chemical effects of water on Earth materials that can be used to infer the effect of water on Earth's surface processes. Examples can include:<br>a) The solubility of different materials in water, which can be used to infer chemical weathering and recrystallization;<br>b) The reaction of iron to rust in water, which can be used to infer the role of |

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| | and empirical models.<br>• 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.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***ESS2.C: The Roles of Water in Earth's Surface Processes***<br>• 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 | | water in chemical weathering; c) Data illustrating that water lowers the melting temperature of most solids, which can be used to infer melt generation; and<br>d) Data illustrating that water decreases the viscosity of melted rock, affecting the movement of magma and volcanic eruptions.<br>b. In their investigation plan, students describe how the data collected will be relevant to determining the effect of water on Earth materials and surface processes.<br>3 Planning for the Investigation<br>a. In their investigation plan, students include a means to indicate or measure the predicted effect of water on Earth's materials or surface processes. Examples include:<br>i. The role of the heat capacity of water to affect the temperature, movement of air and movement of water at the Earth's surface;<br>ii. The role of flowing water to pick up, move and deposit sediment;<br>iii. The role of the polarity of water (through cohesion) to prevent or facilitate erosion;<br>iv. The role of the changing density of water (depending on physical state) to facilitate the breakdown of rock;<br>v. The role of the polarity of water in facilitating the dissolution of Earth materials;<br>vi. Water as a component in chemical reactions that change Earth materials; and<br>vii. The role of the polarity of water in changing the melting temperature and viscosity of rocks.<br>b. In the plan, students state whether the investigation will be conducted individually or collaboratively. |

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| | release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.<br><br>**<u>Crosscutting Concepts</u>**<br>***Structure and Function***<br>• The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. | | 4 Collecting the data<br>a. Students collect and record measurements or indications of the predicted effect of a property of water on Earth's materials or surface.<br>5 Refining the design<br>a. Students evaluate the accuracy and precision of the collected data.<br>b. Students evaluate whether the data can be used to infer the effect of water on processes in the natural world. c If necessary, students refine the plan to produce more accurate and precise data.<br><br>**Activities/ Procedures**<br><br>By way of embedded reading support, inquiry activities that promote scientific thinking, engaging visuals that enhance instruction, adapted ancillary support, and digital instruction, the Learner will:<br><br>• Identify that all transformations of energy create heat.<br>• Define $1^{st}$ and $2^{nd}$ law of thermodynamics.<br>• Calculate heat and final temperature.<br>• Write a scientific explanation of how water affects Earth's surface.<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered. |

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| | | | "Do Nows" to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Textbook Resources:<br>Prentice Hall Chemistry chapter 3<br>Laboratory Manual<br>Core Teaching Resources<br>Small Scale Lab Manual<br>ExamView Pro Test Maker<br>Enrichment: Concept challenge activities<br>Remediation /Instructional Adjustments: Modifications, student difficulties, possible misunderstandings<br>Reading Study Guide |

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| Time/ Terms<br><br>MP 2 | **Big Idea**: Salt Mining |
| | **Topic(s):** Cost-Benefit Ratios; Criteria and Tradeoffs; Salt Mining |

<table>
<tr><td></td><td colspan="3">Goals:<br>1.) Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios<br>2.) Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.</td></tr>
<tr><td></td><td>Standards/Concepts/ CPI<br>Students will be able to:</td><td>Essential Questions/Enduring Understanding</td><td>Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources</td></tr>
<tr><td></td><td>HS-ESS3-2<br><u>Science and Engineering Practices</u><br>Engaging in Argument from Evidence<br>Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.<br>• Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence,</td><td>Essential Questions:<br>What is the best salt mining technique?<br>Enduring Understandings:<br>• 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.<br>• Models can be used to simulate systems and interactions, including energy, matter, and information flows, within and between systems at different scales.<br>• Engineers continuously modify design solutions to increase benefits while decreasing costs and risks.<br>• Analysis of costs and benefits is a critical aspect of decisions about technology.<br>• Scientific 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.<br>• New technologies can have deep</td><td>Objectives<br>TLWBAT:(Observable features of the student performance by the end of the course):<br>• Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).<br>• Use models to evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost–benefit ratios, scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g., economic, societal, environmental, and ethical considerations).<br>Activities/ Procedures<br>The student will use hands-on investigations, problem solving activities, scientific communication, and scientific reasoning to:<br>• Evaluate the different salt mining solutions</td></tr>
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| | and logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).<br><br>**<u>Disciplinary Core Ideas</u>**<br>***ESS3.A: Natural Resources***<br>• 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.<br>***ETS1.B: Developing Possible Solutions***<br>• When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and | impacts on society and the environment, including some that were not anticipated.<br>• Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.<br>• Many decisions are made not using science alone, but instead relying on social and cultural contexts to resolve issues. | based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety,<br>reliability, and aesthetics, as well as possible social, cultural, and environmental impacts in debate notes.<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>"Do Nows" to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Internet Resources<br>English Rubric |

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| | to consider social, cultural, and environmental impacts. (secondary)<br><br>**<u>Crosscutting Concepts</u>**<br>***Connections to Engineering, Technology, and Applications of Science***<br>***Influence of Science, Engineering, and Technology on Society and the Natural World***<br>• Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.<br>• Analysis of costs and benefits is a critical aspect of decisions about technology.<br>***Connections to Nature of Science--Science Addresses Questions About the Natural and Material World***<br>• Science and technology may raise ethical issues | | |

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| | for which science, by itself, does not provide answers and solutions.<br>• 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.<br>• Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.<br><br>**HS-ETS1-1.**<br>**<u>Science and Engineering Practices</u>**<br>***Asking Questions and Defining Problems***<br>Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.<br>• Analyze complex | | |

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| | real-world problems by specifying criteria and constraints for successful solutions.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***ETS1.A: Defining and Delimiting Engineering Problems***<br>• 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.<br>• 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 | | |

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| | manifestations in local communities.<br><br>**<u>Crosscutting Concepts</u>**<br>***Connections to Engineering, Technology, and Applications of Science***<br>***Influence of Science, Engineering, and Technology on Society and the Natural World***<br>• 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. | | |

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| Time/<br>Terms<br><br>Midt. | **Big Idea:** Design a Solution to Make the Production or Use of Rock Salt More Efficient |
| | **Topic(s):** Engineering Design Process |

<table>
<tr><td rowspan="2">Exam</td><td colspan="3">Goals:<br>1.) Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.<br>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.<br>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.</td></tr>
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<tr><td></td><td>HS-ETS1-1.<br><u>Science and Engineering Practices</u><br>Asking Questions and Defining Problems<br>Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.<br>• Analyze complex real-world problems by specifying criteria and constraints for successful solutions.<br><br><u>Disciplinary Core Ideas</u><br>ETS1.A: Defining and</td><td>Essential Questions:<br><br>How can you reduce the impact of environmental problems created by the production and use of road salt?<br><br>Enduring Understandings:<br><br>Engineer and designed solutions are a compromise between criteria and constraints that including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.<br><br>Engineering design process is iterative in nature.<br><br>Engineering notebook is essential to creating a clear and consistent iterative process.</td><td>Objectives<br>TLWBAT:(Observable features of the student performance by the end of the course):<br>• analyze the production and use of road salt to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants in the engineering notebook.<br>• design a solution to solve problems with the production or use of road salt by breaking it down into smaller, more manageable problems that can be solved through engineering in the engineering notebook.<br>• evaluate solutions to the problems with the production and use of road salt 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.<br><br>Activities/ Procedures<br><br>The student will use hands-on investigations, problem solving activities, scientific communication, and scientific reasoning to complete the following:</td></tr>
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| | ***Delimiting Engineering Problems***<br>• 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.<br>• 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.<br><br>**<u>Crosscutting Concepts</u>**<br>***Connections to Engineering, Technology, and Applications of Science Influence of Science,*** | | • define the problem, research the problem, design at least 3 different solutions to the problem, evaluate the 3 possible solutions to the problem, build a model of the chosen solution, test the model, and offer a redesign of the model based on information learned from testing of the model.<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>"Do Nows" to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Internet resources |

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| | ***Engineering, and Technology on Society and the Natural World***<br>• 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.<br><br>**HS-ETS1-2.**<br>**<u>Science and Engineering Practices</u>**<br>***Constructing Explanations and Designing Solutions***<br>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.<br>• Design a solution to a complex real-world problem | | |

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| | based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***ETS1.C: Optimizing the Design Solution***<br>• 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 (tradeoffs) may be needed.<br><br>**HS-ETS1-3.**<br>**<u>Science and Engineering Practices</u>**<br>***Constructing Explanations and Designing Solutions***<br>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 | | |

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| | student-generated sources of evidence consistent with scientific ideas, principles and theories.<br>• Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***ETS1.B: Developing Possible Solutions***<br>• 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.<br><br>**<u>Crosscutting Concepts</u>**<br>***Connections to Engineering, Technology, and Applications of Science***<br>***Influence of Science,*** | | |

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| | ***Engineering, and Technology on Society and the Natural World***<br>• 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. | | |

| Time/ Terms<br><br>MP 3 | **Big Idea:** Stoichiometry | | |
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| | **Topic(s):** The Arithmetic of Equations; Chemical Calculations; Limiting Reagent and Percent Yield | | |
| | **Goals:** 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.] | | |
| | **Standards/Concepts/ CPI**<br>**Students will be able to:** | **Essential Questions/Enduring Understanding** | **Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources** |
| | **HS-PS1-7**<br><br>**<u>Science and Engineering Practices</u>**<br>***Using Mathematics and Computational*** | **Essential Questions:**<br><br>Where do the atoms go during a chemical reaction?<br><br>**Enduring Understandings:** | **Objectives:**<br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>1 Representation<br>a. Students identify and describe the relevant |

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| | ***Thinking***<br>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.<br>• Use mathematical representations of phenomena to support claims.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***PS1.B: Chemical Reactions***<br>• The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and | • The fact that atoms are conserved, together with the knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.<br>• The total amount of energy and matter in closed systems is conserved.<br>• The total amount of energy and matter in a chemical reaction system is conserved.<br>• 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.<br>• Changes of energy and matter in a chemical reaction system can be described in terms of energy and matter flows into, out of, and within that system. | components in the mathematical representations:<br>i. Quantities of reactants and products of a chemical reaction in terms of atoms, moles, and mass;<br>ii. Molar mass of all components of the reaction;<br>iii. Use of balanced chemical equation(s); and<br>iv. Identification of the claim that atoms, and therefore mass, are conserved during a chemical reaction.<br>b. The mathematical representations may include numerical calculations, graphs, or other pictorial depictions of quantitative information.<br>c. Students identify the claim to be supported: that atoms, and therefore mass, are conserved during a chemical reaction.<br>2 Mathematical modeling<br>a. Students use the mole to convert between the atomic and macroscopic scale in the analysis.<br>b. Given a chemical reaction, students use the mathematical representations to<br>i. Predict the relative number of atoms in the reactants versus the products at the atomic molecular scale; and<br>ii. Calculate the mass of any component of a reaction, given any other component.<br>3 Analysis<br>a. Students describe how the mathematical representations (e.g., stoichiometric calculations to show that the number of atoms or number of moles is unchanged after a chemical reaction where a specific mass of reactant is converted to product) support the claim that atoms, and therefore mass, are conserved during a chemical reaction.<br>b. Students describe how the mass of a substance can be used to determine the |

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| | predict chemical reactions.<br><br>**<u>Crosscutting Concepts</u>**<br>***Energy and Matter***<br>• The total amount of energy and matter in closed systems is conserved.<br>***Connections to Nature of Science Scientific Knowledge Assumes an Order and Consistency in Natural Systems***<br>• Science assumes the universe is a vast single system in which basic laws are consistent. | | number of atoms, molecules, or ions using moles and mole relationships (e.g., macroscopic to atomic molecular scale conversion using the number of moles and Avogadro's number).<br><br>**Activities/ Procedures**<br><br>The student will use hands-on investigations, problem solving activities, scientific communication, and scientific reasoning to master the following:<br><br>Interpret a balanced chemical equation<br>Calculating moles of a product<br>Calculating the mass of a product<br>Calculate the theoretical yield of a reaction<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>"Do Nows" to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess |

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| | | | application of concepts and skills.<br><br><br>**Additional Resources/ Materials**<br><br>Textbook Resources:<br>Prentice Hall Chemistry chapter 12<br>Laboratory Manual<br>Core Teaching Resources<br>Small Scale Lab Manual<br>ExamView Pro Test Maker<br>Enrichment: concept challenge activities<br>Remediation/Instructional Adjustments:<br>Modifications, student difficulties, possible misunderstandings<br>Reading Study Guide<br>Kahn Academy |

| Time/ Terms<br><br>MP 3 | Big Idea: Thermal Chemistry | | |
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| | Topic: Exothermic and Endothermic Processes, Thermochemical Equations, Collision Theory, Heat of Reaction, Hess's Law of Summations | | |
| | Goals: 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 molecularlevel 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.] | | |
| | **Standards/Concepts/ CPI<br>Students will be able to:** | **Essential Questions/Enduring Understanding** | **Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources** |

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| | **HS-PS1-4**<br><br>**Science and Engineering Practices**<br>***Developing and Using Models***<br>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.<br>• Develop a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**Disciplinary Core Ideas**<br>***PS1.A: Structure and Properties of Matter***<br>• 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 | **Essential Questions:**<br><br>What is different inside a heat pack and a cold pack?<br><br>**Enduring Understandings:**<br><br>• A stable molecule has less energy than the same set of atoms separated; at least this much energy must be provided in order to take the molecule apart.<br>• 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.<br>• Changes of energy and matter in a chemical reaction system can be described in terms of collisions of molecules and the rearrangements of atoms into new molecules, with subsequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.<br>• 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. | **Objectives**<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>1 Components of the model<br>a. Students use evidence to develop a model in which they identify and describe the relevant components, including:<br>i. The chemical reaction, the system, and the surroundings under study;<br>ii. The bonds that are broken during the course of the reaction;<br>iii. The bonds that are formed during the course of the reaction;<br>iv. The energy transfer between the systems and their components or the system and surroundings;<br>v. The transformation of potential energy from the chemical system interactions to kinetic energy in the surroundings (or vice versa) by molecular collisions; and<br>vi. The relative potential energies of the reactants and the products.<br>2 Relationships<br>a. In the model, students include and describe the relationships between components, including:<br>i. The net change of energy within the system is the result of bonds that are broken and formed during the reaction (Note: This does not include calculating the total bond energy changes.);<br>ii. The energy transfer between system and surroundings by molecular collisions;<br>iii. The total energy change of the chemical reaction system is matched by an equal but opposite change of energy in the surroundings (Note: This does not include calculating the total bond energy changes.); |

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| | molecule apart.<br><br>***PS1.B: Chemical Reactions***<br>• 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.<br><br>**<u>Crosscutting Concepts</u>**<br>***Energy and Matter***<br>• 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. | | and<br>iv. The release or absorption of energy depends on whether the relative potential energies of the reactants and products decrease or increase.<br>3 Connections<br>a. Students use the developed model to illustrate:<br>i. The energy change within the system is accounted for by the change in the bond energies of the reactants and products. (Note: This does not include calculating the total bond energy changes.)<br>ii. Breaking bonds requires an input of energy from the system or surroundings, and forming bonds releases energy to the system and the surroundings.<br>iii. The energy transfer between systems and surroundings is the difference in energy between the bond energies of the reactants and the products.<br>iv. The overall energy of the system and surroundings is unchanged (conserved) during the reaction.<br>v. Energy transfer occurs during molecular collisions.<br>vi. The relative total potential energies of the reactants and products can be accounted for by the changes in bond energy.<br><br>**Activities/ Procedures**<br><br>The student will use hands-on investigations, problem solving activities, scientific communication, and scientific reasoning to master the following:<br><br>Calculate Total Bond Energy/Heat of Reaction of Chemical Reactions<br>Interpret Models by Completing Analogy Maps<br>Develop a Model that Answers the Essential Question |

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| | | | **Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>“Do Nows” to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Textbook Resources:<br>Prentice Hall Chemistry chapter 7<br>Laboratory Manual<br>Core Teaching Resources<br>Small Scale Lab Manual<br>ExamView Pro Test Maker<br>Enrichment: Concept challenge activities<br>Remediation /Instructional Adjustments: Modifications, student difficulties, possible misunderstandings<br>Reading Study Guide |

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<table>
<tr><td rowspan="4">Time/<br>Terms<br><br>MP 4</td><td colspan="3">Big Idea: Reactions Rates and Equilibrium</td></tr>
<tr><td colspan="3">Topic(s): Reaction Rates; Chemical Equilibrium; Reverse Reactions</td></tr>
<tr><td colspan="3">Goals:<br><br>1.) 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.]<br>2.) 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.]</td></tr>
<tr><td>Standards/Concepts/ CPI<br>Students will be able to:</td><td>Essential Questions/Enduring Understanding</td><td>Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources</td></tr>
<tr><td></td><td>HS-PS1-5<br><br><u>Science and Engineering Practices</u><br>Constructing Explanations and Designing Solutions<br>Constructing explanations and designing solutions in</td><td>Essential Questions:<br><br>Is it possible to change the rate of a reaction or cause two elements to react that do not normally want to?<br><br>What can we do to make the products of a reaction stable?</td><td>Objectives<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>HS-PS1-5<br><br>1 Articulating the explanation of phenomena<br>a. Students construct an explanation that</td></tr>
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| | 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.<br>• Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.<br>**<u>Disciplinary Core Ideas</u>**<br>***PS1.B: Chemical Reactions***<br>• 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 | **Enduring Understandings:**<br>• 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.<br>• 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.<br>• Patterns in the effects of changing the temperature or concentration of the reacting particles can be used to provide evidence for causality in the rate at which a reaction occurs.<br>• Much of science deals with constructing explanations of how things change and how they remain stable.<br>• 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.<br>• 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 may be needed.<br>• Explanations can be constructed explaining how chemical reaction systems can change and remain stable. | includes the idea that as the kinetic energy of colliding particles increases and the number of collisions increases, the reaction rate increases.<br>2 Evidence<br>a. Students identify and describe evidence to construct the explanation, including:<br>i. Evidence (e.g., from a table of data) of a pattern that increases in concentration (e.g., a change in one concentration while the other concentration is held constant) increase the reaction rate, and vice versa; and<br>ii. Evidence of a pattern that increases in temperature usually increase the reaction rate, and vice versa.<br>3 Reasoning<br>a. Students use and describe the following chain of reasoning that integrates evidence, facts, and scientific principles to construct the explanation:<br>i. Molecules that collide can break bonds and form new bonds, producing new molecules.<br>ii. The probability of bonds breaking in the collision depends on the kinetic energy of the collision being sufficient to break the bond, since bond breaking requires energy.<br>iii. Since temperature is a measure of average kinetic energy, a higher temperature means that molecular collisions will, on average, be more likely to break bonds and form new bonds.<br>iv. At a fixed concentration, molecules that are moving faster also collide more frequently, so molecules with higher kinetic energy are likely to collide more often.<br>v. A high concentration means that there are more molecules in a given volume and thus more particle collisions per unit of time at |

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| | in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.<br><br>**<u>Crosscutting Concepts</u>**<br>***Patterns***<br>• 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<br><br>**HS-PS1-6**<br><br>**<u>Science and Engineering Practices</u>**<br>***Constructing Explanations and Designing Solutions***<br>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, | | the same temperature.<br><br>**HS-PS1-6**<br>1 Using scientific knowledge to generate the design solution<br>a. Students identify and describe potential changes in a component of the given chemical reaction system that will increase the amounts of particular species at equilibrium. Students use evidence to describe the relative quantities of a product before and after changes to a given chemical reaction system (e.g., concentration increases, decreases, or stays the same), and will explicitly use Le Chatelier's principle, including:<br>i. How, at a molecular level, a stress involving a change to one component of an equilibrium system affects other components;<br>ii. That changing the concentration of one of the components of the equilibrium system will change the rate of the reaction (forward or backward) in which it is a reactant, until the forward and backward rates are again equal; and<br>iii. A description of a system at equilibrium that includes the idea that both the forward and backward reactions are occurring at the same rate, resulting in a system that appears stable at the macroscopic level.<br>2 Describing criteria and constraints, including quantification when appropriate<br>a. Students describe the prioritized criteria and constraints, and quantify each when appropriate. Examples of constraints to be considered are cost, energy required to produce a product, hazardous nature and chemical properties of reactants and products, and availability of resources. |

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| | principles, and theories.<br>• Refine a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***PS1.B: Chemical Reactions***<br>• 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. ETS1.C: Optimizing the Design Solution<br>• 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 (tradeoffs) may be needed. (secondary)<br><br>**<u>Crosscutting Concepts</u>** | | 3 Evaluating potential solutions<br>a. Students systematically evaluate the proposed refinements to the design of the given chemical<br><br>**Activities/ Procedures**<br><br>The student will use hands-on investigations, problem solving activities, scientific communication, and scientific reasoning to master the following:<br><br>Plan and conduct experiments to discover how temperature and concentration affect reaction rates.<br>Write scientific explanations of how temperature and concentration affect reaction rates.<br>Identify Le'Chatelier's Laws to refine a chemical system by specifying a change in conditions that would increase the products.<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>"Do Nows" to generate discussion and to promote the use of effective questioning to assess prior knowledge<br><br>Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics. |

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| | ***Stability and Change***<br>• Much of science deals with constructing explanations of how things change and how they remain stable. | | Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Textbook Resources:<br>Prentice Hall Chemistry chapter 8<br>Laboratory Manual<br>Core Teaching Resources<br>Small Scale Lab Manual<br>ExamView Pro Test Maker<br>Enrichment: Concept challenge activities<br>Remediation /Instructional Adjustments: Modifications, student difficulties, possible misunderstandings<br>Reading Study Guide<br>Internet Resources |

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| Time/ Terms<br><br>MP 4 | **Big Idea:** Photosynthesis and Respiration |
| | **Topic(s):** Photosynthesis, Respiration, Total Bond Energy, Models, Scientific Explanations |
| | **Goals:**<br><br>1.) Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy. [Clarification Statement: Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.] |

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| | [Assessment Boundary: Assessment should not include identification of the steps or specific processes involved in cellular respiration.].<br>2.) Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules. [Clarification Statement: Emphasis is on using evidence from models and simulations to support explanations.] [Assessment Boundary: Assessment does not include the details of the specific chemical reactions or identification of macromolecules.]<br>3.) Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. [Clarification Statement: Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models could include diagrams, chemical equations, and conceptual models.] [Assessment Boundary: Assessment does not include specific biochemical steps.] |

| | Standards/Concepts/ CPI Students will be able to: | Essential Questions/Enduring Understanding | Objectives/Activities/ Procedures/ Assessment/Required Materials/Resources |
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| | **HS-LS1-7**<br><br>**<u>Science and Engineering Practices</u>**<br>***Developing and Using Models*** Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.<br>• Use a model based on evidence to illustrate the relationships between systems or | **Essential Questions:**<br><br>How does the type of food source affect the rate of cellular respiration in yeast?<br><br>How are fatty acids, amino acids, and glucose similar?<br><br>What is responsible for the formation of glucose?<br><br>How does photosynthesis transform light energy into stored chemical energy?<br><br>**Enduring Understandings:**<br>• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.<br>• As a result of these chemical reactions, energy is transferred from | **Objectives:**<br><br>TLWBAT:(Observable features of the student performance by the end of the course):<br><br>**HS-LS1-7**<br><br>1 Components of the model<br>a. From a given model, students identify and describe the components of the model relevant for their illustration of cellular respiration, including:<br>i. Matter in the form of food molecules, oxygen, and the products of their reaction (e.g., water and $CO2$);<br>ii. The breaking and formation of chemical bonds; and<br>iii. Energy from the chemical reactions.<br>2 Relationships<br>a. From the given model, students describe the relationships between components, including:<br>i. Carbon dioxide and water are produced from sugar and oxygen by the process of |

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| | between components of a system.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***LS1.C: Organization for Matter and Energy Flow in Organisms***<br>• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.<br>• 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 | one system of interacting molecules to another.<br>• 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.<br>• Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.<br>• Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.<br>• Sugar molecules 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.<br>• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.<br>• 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.<br>• The process of photosynthesis converts light energy to stored energy by converting carbon dioxide plus water into sugars plus released | cellular respiration; and<br>ii. The process of cellular respiration releases energy because the energy released when the bonds that are formed in CO2 and water is greater than the energy required to break the bonds of sugar and oxygen.<br>3 Connections<br>a. Students use the given model to illustrate that:<br>i. The chemical reaction of oxygen and food molecules releases energy as the matter is rearranged, existing chemical bonds are broken, and new chemical bonds are formed, but matter and energy are neither created nor destroyed.<br>ii. Food molecules and oxygen transfer energy to the cell to sustain life's processes, including the maintenance of body temperature despite ongoing energy transfer to the surrounding environment.<br><br>**HS-LS1-6**<br><br>1 Articulating the explanation of phenomena<br>a. Students construct an explanation that includes:<br>i. The relationship between the carbon, hydrogen, and oxygen atoms from sugar molecules formed in or ingested by an organism and those same atoms found in amino acids and other large carbon-based molecules; and<br>ii. That larger carbon-based molecules and amino acids can be a result of chemical reactions between sugar molecules (or their component atoms) and other atoms.<br>2 Evidence<br>a. Students identify and describe the evidence to construct the explanation, including: |

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| | body temperature despite ongoing energy transfer to the surrounding environment.<br><br>**<u>Crosscutting Concepts</u>**<br>***Energy and Matter***<br>• Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.<br><br>**HS-LS1-6**<br><br>**<u>Science and Engineering Practices</u>**<br>***Constructing Explanations and Designing Solutions***<br>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. | oxygen.<br>• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within a system. | i. All organisms take in matter (allowing growth and maintenance) and rearrange the atoms in chemical reactions.<br>ii. Cellular respiration involves chemical reactions between sugar molecules and other molecules in which energy is released that can be used to drive other chemical reactions.<br>iii. Sugar molecules are composed of carbon, oxygen, and hydrogen atoms.<br>iv. Amino acids and other complex carbon-based molecules are composed largely of carbon, oxygen, and hydrogen atoms.<br>v. Chemical reactions can create products that are more complex than the reactants.<br>vi. Chemical reactions involve changes in the energies of the molecules involved in the reaction. b Students use a variety of valid and reliable sources for the evidence (e.g., theories, simulations, students' own investigations).<br>3 Reasoning<br>a. Students use reasoning to connect the evidence, along with 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, to construct the explanation that atoms from sugar molecules may combine with other elements via chemical reactions to form other large carbon-based molecules. Students describe the following chain of reasoning for their explanation:<br>i. The atoms in sugar molecules can provide most of the atoms that comprise amino acids and other complex carbon-based molecules.<br>ii. The energy released in respiration can be used to drive chemical reactions between |

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| | • 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.<br><br>**Disciplinary Core Ideas**<br>***LS1.C: Organization for Matter and Energy Flow in Organisms***<br>• 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 | | sugars and other substances, and the products of those reactions can include amino acids and other complex carbon-based molecules.<br>iii. The matter flows in cellular processes are the result of the rearrangement of primarily the atoms in sugar molecules because those are the molecules whose reactions release the energy needed for cell processes.<br>4 Revising the explanation<br>a. Given new evidence or context, students revise or expand their explanation about the relationships between atoms in sugar molecules and atoms in large carbon-based molecules, and justify their revision.<br><br>**HS-LS1-5**<br><br>1 Components of the model<br>a. From the given model, students identify and describe the components of the model relevant for illustrating that photosynthesis transforms light energy into stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen, including:<br>i. Energy in the form of light;<br>ii. Breaking of chemical bonds to absorb energy;<br>iii. Formation of chemical bonds to release energy; and<br>iv. Matter in the form of carbon dioxide, water, sugar, and oxygen.<br>2 Relationships<br>a. Students identify the following relationship between components of the given model: Sugar and oxygen are produced by carbon dioxide and water by the process of |

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| | DNA), used for example to form new cells.<br>• As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.<br><br>**<u>Crosscutting Concepts</u>**<br>***Energy and Matter***<br>• 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.<br><br>**HS-LS1-5**<br><br>**<u>Science and Engineering Practices</u>**<br>***Developing and Using Models*** Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their | | photosynthesis.<br>3 Connections<br>a. Students use the given model to illustrate:<br>i. The transfer of matter and flow of energy between the organism and its environment during photosynthesis; and<br>ii. Photosynthesis as resulting in the storage of energy in the difference between the energies of the chemical bonds of the inputs (carbon dioxide and water) and outputs (sugar and oxygen).<br><br>**Activities/ Procedures**<br><br>The student will use hands-on investigations, problem solving activities, scientific communication, and scientific reasoning to master the following:<br><br>Use models to illustrate how cellular respiration in yeast is affected by the food source.<br>Write scientific explanations for how sugar is necessary for the synthesis of amino acids, fatty acids, and other large carbon based molecules.<br>Use models to explain how light energy from the Sun is transformed to chemical energy in plants.<br><br>**Assessments**<br><br>Depending upon the needs of the class, the assessment questions may be answered in the form of essays, quizzes, mobiles, PowerPoint, oral reports, booklets, or other formats of measurement used by the teacher.<br><br>Icebreaker activity to assess knowledge of topic(s) covered.<br><br>“Do Nows” to generate discussion and to promote the use of effective questioning to assess prior knowledge |

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| | components in the natural and designed worlds.<br>• Use a model based on evidence to illustrate the relationships between systems or between components of a system.<br><br>**<u>Disciplinary Core Ideas</u>**<br>***LS1.C: Organization for Matter and Energy Flow in Organisms***<br>• The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.<br><br>**<u>Crosscutting Concepts</u>**<br>***Energy and Matter***<br>• 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. | | Differentiated group and individual work is assigned daily, from various sources.<br><br>Introductory and Closing Activities will be done every day to pre-assess student knowledge and assess understanding of topics.<br><br>Laboratory activities to reinforce and assess application of concepts and skills.<br><br>**Additional Resources/ Materials**<br><br>Argument Driven Chemistry<br>Internet resources<br>Molecular Models |