Grade: 9-12

Unit 2: Understanding Chemical Reactions

New Jersey Student Learning Standards

Established Date 2016-2017
Revised Date 2018-2019
Revised Date 2020-2021
Revised Date 2022-2023

Marking Period	Unit Title	Recommended Instructional Days
2	**Unit 2: Understanding Chemical Reactions**	**46**

NJSLS - Science: *TItle*	NJSLS - Science: *Performance Expectations*	
• **HS-PS1: Matter and Its Interactions** • **HS-PS2: Motion and Stability: Forces and Interactions** • **HS-PS3: Energy** • **HS-ETS1: Engineering Design**	• **HS-PS1-2 -**Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. • **HS-PS1-3 -** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. • **HS-PS1-4 -** Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. • **HS-PS1-5 -** Apply scientific principles and evidence to provide an explanation about the effects of changes the temperature or concentration of the reacting particles on the rate at which a reaction occurs. • **HS-PS1-7 -** Use mathematical representations to support the claim that atoms, and therefore	**Recommended Activities, Investigations, Interdisciplinary Connections, and/or Student Experiences to Explore NJSLS-S within Unit**

	mass, are conserved during a chemical reaction. ● **HS-PS2-4 -** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. ● **HS-PS3-5 -** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. ● **HS-ETS1-1 -** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. ● **HS-ETS1-2 -** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. ● **HS-ETS1-3 -** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	

FOUNDATION Disciplinary: ***Core Idea***	**FOUNDATION Disciplinary:** ***Statement***	
• **HS-PS1.A Structure and Properties of Matter** • **HS-PS1.B Chemical Reactions** • **HS-PS2.B Types of Interactions** • **HS-PS3.C Relationship Between Energy and Forces** • **HS-ETS1.A Delimiting Engineering Problems** • **HS-ETS1.B Developing Possible Solutions** • **HS-ETS1.C Optimizing the Design Solution**	**Structure and Properties of Matter** • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-2) • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3) • A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) **Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by	**Essential Question/s:** • How can the substructures of atoms explain the observable properties of substances? • Why do we quantify matter in different ways? • How is energy used in or obtained from chemical reactions? • How can knowledge of chemical quantities help predict the amounts of reactants required or products formed in a chemical reaction? • What impact does enthalpy and activation energy have on a chemical system? **Activity Description**: **Physical Properties of Matter:** • Inquiry Lab - Correlate Material Properties and Bond Type • Virtual Lab - States of Matter • CER - Relate Intermolecular Forces to States of Matter • Inquiry Lab - Measure the Energy of a Phase Change • Analyzing Data - Analyze Phase Diagrams • Modeling - Phase Changes and Intermolecular Forces • Inquiry Lab - Melt Ionic and Covalent Compounds • CER - Discuss Melting Materials • Engineering Design Challenge - Abrasive Compounds • Inquiry Lab - Modeling Metals, Ceramics, and Polymers • Analyzing Data - Metals and Nonmetals: Data About Their Properties • CER - Make a Claim about Extruded Materials • Engineering Design Challenge - Building a Better Bike • Inquiry Lab - Investigate Surface Tension • Analyzing Data - The Density of Freezing Salt Water • Modeling - Model Surface Tension and Polarity • Analyzing Data - Compare Intermolecular Forces in Fresh and SaltWater • Inquiry Lab - Aqueous Solution • Interactivity - Dissolution rate • Argument Driven Inquiry Lab - Rate of Dissolution: • Modeling - Concentration's Effect on Conductivity

	changes in kinetic energy. (HS-PS1-4), (HS-PS1-5) ● The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-7) **Types of Interactions** ● Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) ● Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4) **Relationship Between Energy and Forces** ● When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)	**Chemical Quantities:** ● Inquiry Lab - Describe Small-scale Matter Using the Mole ● Analyzing Data - Counting Atoms in One Gram ● CER - Discuss the Masses of One Mole ● Guided Inquiry Activity - Relative Mass and the Mole ● Inquiry Lab - Mole Ratios ● Interactivity - Mole Road Map ● Modeling - Model Molar Mass and Molar Volume ● Analyzing Data - Identify an Element From Its Molar Mass ● Inquiry Lab - Determine an Empirical Formula ● Argument Driven Inquiry Lab - Composition of Chemical Compounds: What is the empirical formula of magnesium oxide? ● Analyzing Data - Assess the Percent Composition in DNA ● Modeling - Percent Composition ● Hands-On Lab - Percent Composition of a Compound: What is the percentage of water in popcorn? ● Engineering Design Challenge - An Empirical Formula Challenge ● Inquiry Lab - Preparation of Solutions ● Virtual Lab - Making Dilutions ● Modeling - Model Measures of Concentration ● Analyzing Data - Solubility and Percent by Mass **Chemical Reactions:** ● Collaborative Group Activity - Assigning Oxidation Numbers ● Hands-On Lab - Modeling the Conservation of Mass ● Inquiry Lab - Evaluate Chemical Reactions ● Modeling - Chemical Reactions ● Hands-On Activity - Balancing Equations Using Models ● Analyzing Data - Balance Combustion Equations ● POGIL Guided Inquiry Activity - Types of Chemical Reactions ● Inquiry Lab - Types of Chemical Reactions ● Collaborative Group Activity - The Combustion of Fossil Fuels: How does the combustion of methane compare to the combustion of other hydrocarbon fossil fuels, like coal and oil? [CLIMATE CHANGE] ● Virtual Lab - Reactivity of Metals ● POGIL Guided Inquiry Activity - The Activity Series ● CER - Reaction Reasoning

	Delimiting Engineering Problems ● Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) ● Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) **Optimizing the Design Solution** ● Criteria may need to be broken down into simpler ones that can be approached systematically,	● Inquiry Lab - Predict Chemical Reactions ● Interactivity - Cation Meets Anion ● CER - Predict Whether a Precipitate Will Form ● Argument Driven Inquiry Lab - Identification of Reaction Products: What are the products of the chemical reactions? ● Engineering Design Challenge - Water Purification **Stoichiometry** ● Inquiry Lab - Identify Unknowns Through Stoichiometry ● Analyzing Data - Proportional Relationships in Chemical Reactions ● Modeling - Put it Together ● Inquiry Lab - Determination of Reaction Output ● Interactivity - Understanding Stoichiometry ● Modeling - Choose a Practical Unit ● Inquiry Lab - Formation of Barium Iodate ● Virtual Lab - Limiting Reagent ● Hands-On Lab - Limiting Reactants in a Recipe ● Guided Inquiry Activity - Limiting and Excess Reactants ● Argument Driven Inquiry Lab - Limiting Reactants: Why does mixing reactants in different mole ratios affect the amount of product and the amount of each reactant that is left over? ● Spotlight on George Washington Carver [AMISTAD, DEI] ● CER - A Measure of Success ● Engineering Design Challenge - Build a Film Canister Rocket ● Stoichiometry and Climate Change: How many pounds of CO_2 are added to the atmosphere with the combustion of fossil fuels? Collaborative Group Activity [CLIMATE CHANGE] ● Argument Driven Inquiry Lab - Stoichiometry and Chemical Reactions: Which balanced chemical equation best represents the thermal decomposition of sodium bicarbonate? **Thermochemistry** ● Inquiry Lab - The Thermodynamics of Hand Warmers ● Virtual Lab - Temperature Changes in Chemical Reactions ● Modeling - Energy Changes in Reactions ● Engineering Design Challenge - Flameless Heating Systems ● Inquiry Lab - Hess's Law and the Combustion of a Metal ● Analyzing Data - Energy in Reactions

	and decisions about the priority of certain criteria over others (trade- offs) may be needed. (HS-ETS1-2)	• CER - Compare Heats of Formation • Inquiry Lab - The Heat of Melting Ice • Interactivity - Heat of Fusion • Modeling - Enthalpy Diagrams for Phase Changes • Phase Changes and Climate Change: How has climate change affected glaciers and what has this done to sea levels? [CLIMATE CHANGE]
FOUNDATION **Science and Engineering Practices:** ***Core Idea***	**FOUNDATION** **Science and Engineering Practices:** ***Statement***	**<u>Interdisciplinary Connections:</u>** ***Connections to NJSLS – English Language Arts***
• **SEP-1 Asking Questions and Defining Problems** • **SEP-2 Planning and Carrying Out Investigations** • **SEP-4 Developing and Using Models** • **SEP-5 Constructing Explanations and Designing Solutions** • **SEP-7 Using Mathematics and Computational Thinking**	**Asking Questions and Defining Problems** • Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **Planning and Carrying Out Investigations** • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3) **Developing and Using Models** • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4)	• **RST.11-12.1** Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS- PS1-5) • **WHST.9-12.2** Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)(HS-PS1-5) • **WHST.9-12.5** Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2) • **WHST.9-12.7** Conduct short as well as more sustained research projects to answer a question (including a self- generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3) (HS-PS3-5)(HS-ESS2-5) • **WHST.11-12.8** Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS1-3)(HS-PS3-5) • **WHST.9-12.9** Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)(HS-PS3-5)

	• Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-5) **Constructing Explanations and Designing Solutions** • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) • Design and evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) **Using Mathematics and Computational Thinking**	• **SL.11-12.5** Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)(HS-PS3-5) ***Connections to NJSLS – Mathematics*** • **MP.2** Reason abstractly and quantitatively. (HS-PS1-5)(HS-PS1-7) (HS-PS2-4)(HS-PS3-5) • **MP.4** Model with mathematics. (HS-PS1-4)(HS-ETS1-2)(HS-PS2-4) (HS-PS3-5) • **HSN-Q.A.1** Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2)(HS-PS1-3)(HS-PS1-4) (HS-PS1-5)(HS-PS1-7) (HS-PS2-4) • **HSN-Q.A.2** Define appropriate quantities for the purpose of descriptive modeling (HS-PS1-4)(HS-PS1-7)(HS-PS2-4) • **HSN-Q.A.3** Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2)(HS-PS1-3) (HS-PS1-4)(HS-PS1-5)(HS-PS1-7)(HS-ESS3-5)

	● Use mathematical representations of phenomena to support claims. (HS-PS1-7) (HS-PS2-4)	
FOUNDATION **Crosscutting Concepts:** ***Core Idea***	**FOUNDATION** **Crosscutting Concepts:** ***Statement***	
● **CCC-1 Patterns** ● **CCC-2 Cause and Effect** ● **CCC-5 Energy and Matter**	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-2)(HS-PS1-3)(HS-PS1-5)(HS-PS2-4) **Cause and Effect** ● Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5) **Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. (HS-PS1-7) ● Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)	
Social and Emotional Learning: ***Competencies***	**Social and Emotional Learning:** ***Sub-Competencies***	

● **Self-Awareness** ● **Self-Management** ● **Social Awareness** ● **Responsible Decision-Making** ● **Relationship Skills**	● Recognize the impact of one's feelings and thoughts on one's own behavior ● Recognize one's personal traits, strengths, and limitations ● Recognize the skills needed to establish and achieve personal and educational goals ● Demonstrate an awareness of the differences among individuals, groups, and others' cultural background ● Demonstrate an understanding of the need for mutual respect when viewpoints differ ● Develop, implement, and model effective problem-solving and critical thinking skills ● Identify the consequences associated with one's actions in order to make constructive choices ● Utilize positive communication and social skills to interact effectively with others ● Identify ways to resist inappropriate social pressure	

Assessments (Formative) ***To show evidence of meeting the standard/s, students will successfully engage within:***	**Assessments (Summative)** ***To show evidence of meeting the standard/s, students will successfully complete:***
Formative Assessments: ● Guided Inquiry Activities ● CER Tasks ● Virtual Labs ● Data Analysis Activities ● Group Discussions ● Lab Notebook ● Experience Notebook	**Benchmarks:** ● Chemistry Diagnostic Assessment ● Chemistry District Assessments **Summative Assessments:** ● Unit Assessment - Physical Properties of Matter ● Unit Assessment - Chemical Quantities ● Unit Assessment - Chemical Reactions

• Engineering Design Challenges • Lesson Checks • Lesson Quizzes	• Unit Assessment - Stoichiometry • Unit Assessment - Thermochemistry • Collaborative Group Project(s)

Differentiated Student Access to Content:
Teaching and Learning *Resources/Materials*

Core Resources	**Alternate Core Resources** ***IEP/504/At-Risk/ESL***	**ELL Core Resources**	**Gifted & Talented Core Resources**
• Experience Chemistry TE • Experience Chemistry SE • POGIL Activities for High School Chemistry • Argument Driven Inquiry in Chemistry: Lab Investigations for Grades 9-12 • Student Chromebooks • Evidence Notebooks	• Auditory Aids • Visual Aids • Science Glossary and Thesaurus • Picture Glossary • Manipulatives • Virtual Nerd	• Multilingual Science Glossary and Thesaurus • Picture Glossary • BrainPOP ELL • Khan Academy En Español	• Chemistry for the Gifted and Talented • Crash Course

Supplemental Resources

Technology:
- Schoology
- Google Apps for Education
- SMARTBoard
- Calculators

Other:
- Teacher created video tutorials
- American Association for the Advancement of Science
- American Chemical Society
- Concord Consortium: Virtual Simulations
- International Technology and Engineering Educators Association
- National Earth Science Teachers Association
- National Science Digital Library
- National Science Teachers Association
- North American Association for Environmental Education
- Phet: Interactive Simulations
- Science NetLinks

Differentiated Student Access to Content: **Recommended *Strategies & Techniques***			
Core Resources	**Alternate Core Resources** ***IEP/504/At-Risk/ESL***	**ELL Core Resources**	**Gifted & Talented Core**
• Restructure lessons using UDL principles • Structure lessons around questions that are authentic, relate to students' interests, social/family background and knowledge of their community • Provide students with multiple choices for how they can represent their understandings • Provide opportunities for students to connect with people of similar backgrounds • Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures • Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understanding • Use project-based science learning to connect science with observable phenomena • Structure learning around explaining or solving a social or community-based issue • Collaborate with after-school programs or clubs to extend learning opportunities	• Utilize a multi-sensory (VAKT) approach during instruction • Provide alternate presentations of skills by varying the method (repetition, simple explanations, additional examples, modeling, etc.) • Modify test content and/or format • Allow students to retake test or make corrections to test for additional credit • Provide extended time • Provide preferential seating as needed • Review, restate and repeat directions • Provide study guides, and/or break assignments into segments of shorter tasks • Deliver instruction utilizing varied learning styles including audio, visual, and tactile/kinesthetic • Provide individual instruction as needed • Provide modified assessments and/or rubrics when needed	• Provide extended time • Provide preferential seating as needed • Provide positive reinforcement • Check often for understanding of and/or review of course objectives • Provide oral/visual directions/prompts when necessary • Provide students with multiple literacy strategies • Provide supplemental materials including use of an online bilingual dictionary • Offer choices of what students can say when they are called on and aren't sure how to respond • Integrate project-based learning to enhance hands-on activities, peer interaction, rich language use, and opportunities to explore personal interests • Provide modified assessments and/or rubrics when needed • Repeat instructions as needed • Provide individual instruction as needed	• Create an enhanced set of introductory activities • Implement a multi-level and multi-dimensional curriculum • Create tiered assignments • Integrate active teaching/learning opportunities • Incorporate authentic components • Propose interest-based extension activities • Infuse enrichment activities • Build in time for flexible learning groups • Embrace creative questioning • Explore many points of view about contemporary topics and allow opportunity to analyze and evaluate materia • lEncourage self directed learning • Connect students to related talent development opportunities

NJSLS CAREER READINESS, LIFE LITERACIES & KEY SKILLS	**Disciplinary Concept:**	
	Core Ideas:	**Creativity and Innovation** ● With a growth mindset, failure is an important part of success. **Critical Thinking and Problem-solving** ● Collaboration with individuals with diverse experiences can aid in the problem-solving process, particularly for global issues where diverse solutions are needed. **Global and Cultural Awareness** ● Solutions to the problems faced by a global society require the contribution of individuals with different points of view and experiences. Digital tools such as artificial intelligence, image enhancement and analysis, and sophisticated computer modeling and simulation create new types of information that may have profound effects on society. These new types of information must be evaluated carefully. **Information and Media Literacy** ● Digital tools such as artificial intelligence, image enhancement and analysis, and sophisticated computer modeling and simulation create new types of information that may have profound effects on society. These new types of information must be evaluated carefully. ● In order for members of our society to participate productively, information needs to be shared accurately and ethically. ● Accurate information may help in making valuable and ethical choices.
	Performance Expectation/s:	**Creativity and Innovation** ● 9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a). **Critical Thinking and Problem-solving** ● 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3). ● 9.4.12.CT.3: Enlist input from a variety of stakeholders (e.g., community members, experts in the field) to design a service learning activity that

addresses a local or global issue (e.g., environmental justice).

Global and Cultural Awareness

- 9.4.12.GCA.1: Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).

Information and Media Literacy

- 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)
- 9.4.12.IML.5: Evaluate, synthesize, and apply information on climate change from various sources appropriately (e.g., 2.1.12.CHSS.6, S.IC.B.4, S.IC.B.6, 8.1.12.DA.1, 6.1.12.GeoHE.14.a, 7.1.AL.PRSNT.2).
- 9.4.12.IML.7: Develop an argument to support a claim regarding a current workplace or societal/ethical issue such as climate change (e.g., NJSLSA.W1, 7.1.AL.PRSNT.4).

Career Readiness, Life Literacies, & Key Skills Practices

- Act as a responsible and contributing community member and employee.
- Attend to financial well-being.
- Consider the environmental, social and economic impacts of decisions.
- Demonstrate creativity and innovation.
- Utilize critical thinking to make sense of problems and persevere in solving them.
- Model integrity, ethical leadership and effective management.
- Plan education and career paths aligned to personal goals.
- Use technology to enhance productivity, increase collaboration and communicate effectively.
- Work productively in teams while using cultural/global competence.

New Jersey Legislative Statutes and Administrative Code
(place an “X” before each law/statute if/when present within the curriculum map)

X	Amistad Law: *N.J.S.A. 18A 52:16A-88*		Holocaust Law: *N.J.S.A. 18A:35-28*		LGBT and Disabilities Law: *N.J.S.A. 18A:35-4.35*	X	Diversity & Inclusion: *N.J.S.A. 18A:35-4.36a*	X	Standards in Action: *Climate Change*