Chemistry

New Jersey
Student Learning Standards
SCIENCE

All standards are NJSLS-S

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Unit 1: Overview
Unit 1: Interactions of matter
Content Area: Chemistry
Pacing: 16 Weeks
Essential Questions
1. What are the proper techniques for measuring in a chemistry lab? 2. How can the periodic table be used to predict properties of substances? 3. What does the movement of electrons cause? 4. How do bond types vary?
Student Learning Objectives (Performance Expectations)
HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
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-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
Unit Summary
By the end of this unit, students will: · define various properties of matter . understand the arrangement of the periodic table . identify patterns in the periodic table By the end of this unit, students will be able to: · identify a substance's properties · calculate density, average atomic mass, energy, wavelength,and frequency . write electron configurations . name and write formulas of compounds
Technical Terms

Chemistry, physical/chemical property, physical/chemical changes, intensive, extensive, qualitative, quantitative, element, compound, homogeneous/heterogeneous mixtures, solution, alloy, colloid, accuracy, precision, systematic/random error, percent error, atom, molecule, proton, neutron, electron, Bohr model, excited state, ground state, quantum mechanical model, electron configuration, Hund's rule, Pauli exclusion principle, aüfbau rule, ionic/covalent/metallic bond, ionic/molecular compound, Lewis dot structure, intra/intermolecular force, Van der Waals/London dispersion forces, dipole-dipole/ion-dipole interaction, hydrogen bond

Formative & Summative Assessment Measures

Potential Assessments:

- Interim mini-assessments
- Intro "classify it" activity/lab
- Inquiry Labs
- Density/Graphing Lab
- Scientific connection to specific effects in film
- See Chemistry Timeline for more activities

Interdisciplinary Connections

NJSLS- ELA	NJSLS- Mathematics
RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. (HS-PS1-1) RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3) WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1- 2) WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and	Mathematics – 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) HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-2),(HS-PS1-3) 21st Century Skills- 9.2.12.C.1 Review career goals and determine steps necessary for attainment. 9.2.12.C.3 Identify transferable career skills and design alternate career plans. 9.1.12.A.3 Analyze the relationship between various careers and personal earning goals 9.1.12.A.4 Identify a career goal and develop a plan and timetable for achieving it, including educational/training requirements, costs, and possible debt 9.1.12.A.5 Analyze how the economic, social, and political conditions of a time period can

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) 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) WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3) WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS4-5)	affect the labor market.
Core Instructional Materials	Can include: NJCTL Presentations/Classwork, Lab Materials,textbook, Videos, etc.
21st Century Life and Careers	9.3.ST.2; 9.3.ST.ED.2; 9.3.ST-ET5
Technology Standards	8.1.12.D.1; 8.2.12.E.1; 8.1.12.F.1

Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Scaffolding Word Walls Sentence/paragraph frames Bilingual dictionaries/translation Think alouds Highlight key vocabulary Annotation guides Think-pair-share	Word Walls - chapter specific vocabulary, general science terms Visual Aids - powerpoint, videos, demonstrations Graphic Organizers - classification of matter flow chart, foldables (scientific method, periodic table families, atoms & matter, atomic	Teacher tutoring Peer tutoring Study guides Heterogeneous Groups Graphic organizers Extended time Parent communication	Curriculum compacting Challenge assignments Enrichment activities Tiered activities Independent research/Inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks

Visual aids Modeling See the Activity Handbook Multimedia - native language in Kahn Academy (properties, electrons, periodic table, bonding) See Fanelli for a copy of a Chemistry textbook, has both English and Spanish editions	number, particles in atoms, phys/chem properties/changes, atomic mass three ways, history of the atom) - copyrighted file - hard copies available from Fanelli Multimedia Kahn Academy - Properties, Electrons, Periodic Table, Bonding Leveled readers Assistive technology Notes/summaries - share via powerpoint, handwritten, via cloud-based services (ex OneNote) Extended time Answer masking Answer eliminator Highlighter Color Contrast Teacher tutoring Peer tutoring Parent communication Modified assignments (provide formulas, use of calculator, provide data tables, exemplar samples of projects,, lower number of questions/simplify questions, etc) Counseling See the Activity Handbook Games (chemistry football, electron configuration battleship, electron orbital game, ion poker, periodic trend war, Kahoot, Jeopardy) pHet labs - isotopes and atomic	Modified assignments	Self-directed activities SAT II questions T/F/CE Atomsmith online classroom simulations (quantum model of the atom)

	mass, build an atom, density, photoelectric effect, models of the hydrogen atom SAS V-Lab - density, atomic structure, electron transitions		

Students who demonstrate understanding can:

HS-PS1-1. **Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.** [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [*Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

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.

- Use a model to predict the relationships between systems or between components of a system.

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.
- 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.

Crosscutting Concepts

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.

Connections to other DCIs in this grade-band:
HS.LS1.C

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Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS1.B**

Common Core State Standards Connections:
ELA/Literacy -

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. *(HS-PS1-1)*

Students who demonstrate understanding can:

HS-PS1-3. **Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.** [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [*Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan 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.	**PS1.A: Structure and Properties of Matter** • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS2.B: Types of Interactions** • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. *(secondary)*	**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.

Connections to other DCIs in this grade-band:
HS.ESS2.C

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS2.B**

Common Core State Standards Connections:
ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-3)

WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS1-3)

WHST.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)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3)*

Mathematics -

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Cliffside Park Public Schools

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BOE APPROVAL: 8/2018

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-PS1-3)*

Students who demonstrate understanding can:

HS-PS4-5. **Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*** [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [*Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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Cliffside Park Public Schools

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BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Obtaining, Evaluating, and Communicating Information 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. • Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**PS3.D: Energy in Chemical Processes** • Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. *(secondary)* **PS4.A: Wave Properties** • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. **PS4.B: Electromagnetic Radiation** • Photoelectric materials emit electrons when they absorb light of a high-enough frequency. **PS4.C: Information Technologies and Instrumentation** • Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	**Cause and Effect** • Systems can be designed to cause a desired effect. - ***Connections to Engineering, Technology, and Applications of Science*** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). **Influence of Engineering, Technology, and Science on Society and the Natural World** • Modern civilization depends on major technological systems.

Connections to other DCIs in this grade-band:
HS.PS3.A

Articulation of DCIs across grade-bands:
MS.PS4.A ; **MS.PS4.B** ; **MS.PS4.C**

Common Core State Standards Connections:
ELA/Literacy -
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-PS4-5)*

SUBJECT: SCIENCE/Chemistry

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5E Model	
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-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. HS- ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surface to construct an account of Earth's formations and early history.	
Engage Anticipatory Set	Anticipatory Set - A nucleus contains protons and neutrons, and electrons are outside the nucleus. - The periodic table contains elements, an atomic number and an atomic mass. - Compounds are a combination of elements. - Definition of quantitative and qualitative - Light can be a wave and a particle - Definition of wavelength, frequency, amplitude and speed of light. - Basic relationship between frequency, wavelength and speed of light. - Bonding is the combining of elements into a compound and is required for all chemical reactions. Common Misconceptions: - The nucleus only contains the neutrons. - Mass number and atomic mass are not the same thing. One is on the periodic table and the other is not. - Heterogeneous and homogenous often get mixed up. Students can't always remember which is multi-layered and which is not. - Students sometimes mix up which number is an atomic number and which is a mass number in an isotope symbol. - Energy is related to frequency not wavelength directly. - The photoelectric effect leads to the discovery of solar panels not anything to do with cameras. - Quantum numbers are really letters - Covalent bonds are between two nonmetals whereas ionic bonds are between one metal and one nonmetal. - The students occasionally mix up the prefixes used for naming covalent bonds (specifically six and seven). - Students forget when naming ionic bonds to include the Roman numeral as a charge for transition metals - Students also forget all the special ionic elements- tin, lead, silver, zinc, and Mercury.

	- When drawing Lewis structures for covalent bonds students get overzealous and always want to add triple bonds- even when they are not needed.
Exploration Student Inquiry	<u>Planning and Carrying out Investigations:</u> ● Students will practice and hone appropriate lab skills in the opening lab activity. <u>Obtaining , Evaluating, and Communicating Information:</u> ● Students will make measurements and observations in the opening lab activity, and then explain what their observations indicate about the substances. <u>Developing and Using Models:</u> ● Students will develop models of the atom to show where electrons, protons, and neutrons are located and how they interact with each other. <u>Constructing Explanations and Designing Solutions:</u> ● Students will create models for labeling physical and chemical properties
Explanation Concepts and Practices	Measurements are made with one estimated number. Bunsen burners should be adjusted before and after sparking with the gas on. Don't leave the gas on if you aren't ready to make a spark for a flame. Solutions can be poured and measured with different accuracies in graduated cylinders, beakers, and test tubes Substances can be identified by their physical and chemical properties. There are five signs of a chemical change (bubbles, precipitate, odor, color, temperature). Matter is classified as pure (element, compound), or a mixture (homogeneous, heterogeneous) Protons can be identified using the atomic number as can electrons (when it is an atom). Neutrons must be calculated using the mass number of the isotope. Location on the periodic table can help a person predict an element's chemical or physical properties as well as its atomic structure. Photoelectric effect is what causes the elements to emit specific colors. Valence electrons can be determined by how many electrons an element needs to gain or lose to become noble. The Bohr model shows that excited electrons lose energy in the form of photons Covalent bonds are between two nonmetals; Ionic bonds are between a metal and a nonmetal. Covalent bonds do not conduct electricity and have low melting and boiling points; whereas ionic bonds do conduct electricity in the aqueous form and have high melting and boiling points. Ionic bonds must have a net zero charge overall. This math is what determines how many of each element there is in a compound.

	Covalent bonds use prefixes when naming to identify the number of elements in the compound.
Elaboration Extension Activity	NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	Potential Assessments: - Interim mini-assessments - Intro "classify it" activity/lab - Inquiry Labs - Density/Graphing Lab - Scientific connection to specific effects in film - See Chemistry Timeline for more activities
Resources	Resources: http://www.goscienceseven.com/Tools/flamelabburners/flamelab.html http://www.chemistryland.com/CHM130FieldLab/Lab4/Lab4.html https://www.oakland.k12.mi.us/Portals/0/Learning/AtomicTheoryStructure.pdf http://www.sciencechannel.com/tv-shows/greatest-discoveries/videos/100-greatest-discoveries-radiometric-dating/ http://www.mhhe.com/biosci/genbio/virtual_labs/BL_17/BL_17.html http://www.crime-scene-investigator.net/carbon-14datingtorecenthumanremains.pdf https://www.youtube.com/watch?v=muxRZ1irsrk http://www.explainthatstuff.com/how-photoelectric-cells-work.html http://www.browndoggadgets.com/blogs/resources/14901705-diy-solar-usb-charger-altoids https://www.youtube.com/watch?v=QIfTT-_-xLo http://www.chemistryland.com/CHM130FieldLab/Lab10/Lab10.html

SUBJECT: SCIENCE/Chemistry

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GRADE: 9-12

BOE APPROVAL: 8/2018

Unit 2: Overview
NJSLS Unit 2: Chemical Reactions & Quantitative Relationships of Matter
Content Area: Chemistry
Pacing: 6 Weeks
Essential Questions
1. How is mass affected in a chemical reaction? 2. What is involved in a chemical reaction and how are they classified? 3. How do we quantify reactions? 4. How much of a gas is present after a chemical change?
Student Learning Objectives (Performance Expectations)
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-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
HS- ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surface to construct an account of Earth's formations and early history.
Unit Summary
By the end of this unit, students will know: - How to convert between moles, molecules, grams, and volume at STP - How to calculate a compound's empirical formula (honors) - How to calculate a compound's percent composition by mass - How to perform various stoichiometric calculations By the end of this unit, students will be able to: - convert between moles, molecules, grams, and volume at STP - calculate a compound's empirical formula (honors) - calculate a compound's percent composition by mass - perform various stoichiometric calculations such as amount of product produced, amount of reactant(s) needed, limiting reactant, excess remaining etc
Technical Terms
Gram, mole, molar mass, standard temperature and pressure, stoichiometry, reactant, product, empirical/molecular formula, percent composition
Formative & Summative Assessment Measures

Potential Assessments:

- Interim mini-assessments
- Conservation of Mass Lab
- Inquiry Labs and activities
- See Chemistry Timeline for additional activities

Interdisciplinary Connections	
NJSLS- ELA	**NJSLS- Mathematics**
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-ESS1-6) RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-6) WHST.9-12.1 Write arguments focused on discipline-specific content. (HS-ESS1-6)	MP.2 Reason abstractly and quantitatively. (HS-PS1-7) (HS-ESS2-6)(HS-ESS1-6) MP.4 Model with mathematics. (HS-ESS2-6) 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-PS1-7)(HS-ESS2-6) (HS-ESS1-6) HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-7)(HS-ESS2-6) (HS-ESS1-6) HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-7)(HS-ESS2-6) (HS-ESS1-6) HSF-IF.B.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. (HS-ESS1-6) HSS-ID.B.6 Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. (HS-ESS1-6)
Core Instructional Materials	Can include: Presentations/Classwork, Lab Materials, Videos, etc.
21st Century Life and Careers	9.3.ST.2; 9.3.ST.ED.2; 9.3.ST-ET5
Technology Standards	8.1.12.D.1; 8.2.12.E.1; 8.1.12.F.1

Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Scaffolding Word Walls	Word Walls chapter specific Visual Aids powerpoint, videos, demonstrations	Word Walls chapter specific Visual Aids powerpoint, videos, demonstrations	Curriculum compacting Challenge assignments Enrichment activities

Sentence/paragraph frames Bilingual dictionaries/translation Think alouds Highlight key vocabulary Annotation guides Think-pair-share Visual aids Modeling See the Activity Handbook Multimedia Kahn Academy in native language (see topics in special education) See Fanelli for a copy of a Chemistry textbook, has both English and Spanish editions Flow Charts (Mini Guide to Problem Solving chapters 5, 7, 8, 9, 10)	Graphic Organizers Multimedia Leveled readers Assistive technology Notes/summaries - share via powerpoint, handwritten, via cloud-based services (ex OneNote) Extended time Answer masking Answer eliminator Highlighter Color Contrast Teacher tutoring Peer tutoring Parent communication Modified assignments (provide formulas, use of calculator, provide data tables, exemplar samples of projects,, lower number of questions/simplify questions, etc) Counseling See the Activity Handbook Games (Stoichiometry relay, whiteboard races, Kahoot, Jeopardy) Flow Charts (Mini Guide to Problem Solving chapters 5, 7, 8, 9, 10) pHet labs - molecular shapes, molecular shapes basics, molecule polarity, reactants products & leftovers SAS V-Lab - Chemical equations, precipitation reactions, chemical	Graphic Organizers Multimedia Leveled readers Assistive technology Notes/summaries - share via powerpoint, handwritten, via cloud-based services (ex OneNote) Extended time Answer masking Answer eliminator Highlighter Color Contrast Teacher tutoring Peer tutoring Parent communication Modified assignments (provide formulas, use of calculator, provide data tables, exemplar samples of projects,, lower number of questions/simplify questions, etc) Counseling See the Activity Handbook Games (Stoichiometry relay, whiteboard races, Kahoot, Jeopardy) Flow Charts (Mini Guide to Problem Solving chapters 5, 7, 8, 9, 10) pHet labs - molecular shapes, molecular shapes basics, molecule polarity, reactants products & leftovers SAS V-Lab - Chemical equations, precipitation reactions, chemical nomenclature, empirical/molecular formulas, limiting reactants	Tiered activities Independent research/Inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks Self-directed activities SAT II questions T/F/CE

	nomenclature, empirical/molecular formulas, limiting reactants		

Students who demonstrate understanding can:

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. [Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [*Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

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

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.

Disciplinary Core Ideas

PS1.A: 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.

PS1.B: Chemical Reactions

- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.

Crosscutting Concepts

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.

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Connections to other DCIs in this grade-band:
HS.LS1.C ; **HS.ESS2.C**

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS1.B**

Common Core State Standards Connections:

ELA/Literacy -

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2)

WHST.9-12.5 Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience. (HS-PS1-2)

Mathematics -

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)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-2)*

Students who demonstrate understanding can:

HS-PS1-7. **Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.** [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [*Assessment Boundary: Assessment does not include complex chemical reactions.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

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Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to support claims.	**PS1.B: Chemical Reactions** • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved. - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Science assumes the universe is a vast single system in which basic laws are consistent.

Connections to other DCIs in this grade-band:
HS.LS1.C ; **HS.LS2.B** ; **HS.PS3.B**

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS1.B** ; **MS.LS1.C** ; **MS.LS2.B** ; **MS.ESS2.A**

Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-PS1-7)
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-PS1-7)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-PS1-7)*
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-7)*

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Students who demonstrate understanding can:

HS-ESS1-6. **Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.** [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. - ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ● A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. ● Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.	**ESS1.C: The History of Planet Earth** ● Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. **PS1.C: Nuclear Processes** ● Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. *(secondary)*	**Stability and Change** ● Much of science deals with constructing explanations of how things change and how they remain stable.
Connections to other DCIs in this grade-band: **HS.PS2.A** ; **HS.PS2.B**		
Articulation of DCIs across grade-bands: **MS.PS2.B** ; **MS.ESS1.B** ; **MS.ESS1.C** ; **MS.ESS2.A** ; **MS.ESS2.B**		

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-ESS1-6)*

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS1-6)

WHST.9-12.1 Write arguments focused on *discipline-specific content.* (HS-ESS1-6)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS1-6)

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-ESS1-6)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS1-6)*

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS1-6)

HSF-IF.B.5 Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. *(HS-ESS1-6)*

HSS-ID.B.6 Represent data on two quantitative variables on a scatter plot, and describe how those variables are related. *(HS-ESS1-6)*

Students who demonstrate understanding can:

HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**ESS2.D: Weather and Climate** • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Energy and Matter** • The total amount of energy and matter in closed systems is conserved.

Connections to other DCIs in this grade-band:
HS.PS1.A ; **HS.PS1.B** ; **HS.PS3.D** ; **HS.LS1.C** ; **HS.LS2.B** ; **HS.ESS3.C** ; **HS.ESS3.D**

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS3.D** ; **MS.PS4.B** ; **MS.LS2.B** ; **MS.ESS2.A** ; **MS.ESS2.B** ; **MS.ESS2.C** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-6)
MP.4	Model with mathematics. (HS-ESS2-6)
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-ESS2-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-6)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-6)

5E Model

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-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

HS- ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

SUBJECT: SCIENCE/Chemistry **Cliffside Park Public Schools** GRADE: 9-12

BOE APPROVAL: 8/2018

HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surface to construct an account of Earth's formations and early history.	
Engage Anticipatory Set	Prior Knowledge: ● Five signs of a chemical reaction ● Unit conversions, dimensional analysis, percentages ● Ions and writing chemical formulas ● States of matter, properties of materials ● Significant figures and labeling units Common Misconceptions: ● Students often switch the numbers in equalities when translating them into conversion factor format. ● Students sometimes have difficulty recognizing what a question is asking for. Going over how to figure out which problem solving route is needed from the information given is really helpful. ● Students might think that the molar mass represents the mass of a substance involved in a chemical reaction or that the coefficient has to be included in the molar mass. ● Students often forget to use appropriate parentheses and enter numbers with exponents incorrectly into calculator. Order of operations matters if you are using avogadro's number. ● Students might try to memorize the steps for solving every type of stoichiometry problem rather than trying to use logic and unit analysis to determine the problem solving pathway.
Exploration Student Inquiry	<u>Analyzing and Interpreting Data</u> ● Students interpret data to consider mass conservation <u>Constructing Explanations</u> ● Comparing open and closed system data to state matter is conserved in a closed system <u>Developing and Using Models</u> ● Students predict products based on models of reaction types <u>Using Mathematics and Computational Thinking</u> ● Students use mathematics to prove relationships between chemical quantities. <u>Constructing Explanations and Designing Solutions</u> ● Students use scientific knowledge to find a way to predict how much carbon is in the atmosphere and suggest a way to improve the situation.

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Explanation Concepts and Practices	Matter is never created, nor destroyed, in a chemical reaction Chemical reactions cause rearrangement of the atoms involved An open system may cause a seeming loss of mass Reactions are balanced to show conservations of mass Reactions can usually be classified as 1 of 5 major types Signs of chemical reactions are not unique to any type of reaction Products of chemical reactions may be predicted based on type of reaction The amount of a substance is based on the mole, rather than mass The amounts of substances in a reaction can be determined with a balanced equation Percent yield determines reaction efficiency Compounds can be compared by their percentages of elements Gases are assumed to behave according to the Kinetic Molecular Theory Pressure units and conversions The measurements of gas in a container can be determined with the Ideal Gas Law Develop a model to describe carbon cycling in various layers of the atmosphere (gas stoichiometry) Ratios between elements determine compound formula
Elaboration Extension Activity	NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	Potential Assessments: ● Interim mini-assessments ● Conservation of Mass Lab ● Inquiry Labs and activities ● See Chemistry Timeline for additional activities
Resources	http://www.rsc.org/chemistryworld/2015/08/arsenic-agatha-christie-poisons The Martian: book by Andy Weir or movie from 2015 Living by Chemistry book: Weather Unit Conservation of Mass Demo Conservation of Mass Video Ideal Gas Constant Lab

	Percent Yield Lab Limiting Reactant Simulations Types of Chemical Reactions Lab Balancing Equations Simulation

Solutions and Equilibrium

Unit 3: Solutions and Equilibrium

Content Area: Chemistry

Pacing: 4 weeks (H); 5 weeks combined with unit 4 (CP)

Essential Question

1. How can varying the concentration affect the rate of reaction?
2. Are the toxins in the public water supply enough to cause concern?
3. How can just salt and ice be used to turn milk into ice cream?
4. How do acids and bases affect life?
5. How does equilibrium work in the body?
6. How do humans affect Earth's equilibrium?

Student Learning Objectives (Performance Expectations)

HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
HS- ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.
HS- PS1- 6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.

Unit Summary

By the end of this unit, students will know:

- Various ways concentration can be measured.

- How colligative properties effect properties of matter.
- Ways to shift equilibrium
- How to define acids/bases 3 ways
- How to complete a titration
- Describe the common ion effect

By the end of this unit, students will be able to:

- Calculate concentration (% solutions, molarity, molality, ppm).
- Solve dilution problems.
- Calculate how much boiling/freezing point change when solutes are added to a solution.
- Perform pH calculations.
- Write net ionic equations

Technical Terms

Solution, colloid, suspension, solubility, concentration, percent solution, ppm, molarity, molality, colligative property, osmosis, vapor pressure, Arrhenius acid/base, Bronsted Lowry acid/base, Lewis acid/base, conjugate pair, titration, common-ion, net ionic equation, polarity, Lewis structure

Formative & Summative Assessment Measures

Potential Assessments:

- Interim mini-assessments
- Inquiry Labs
- See Chemistry Timeline for additional activities

Interdisciplinary Connections

NJSLS- ELA	NJSLS- Mathematics
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)	MP.2 Reason abstractly and quantitatively. (HS-PS1-5)
WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-PS1-5)*	IHSN-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-PS1-5)*
	HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-5)*

Core Instructional Materials	Can include: NJCTL Presentations/Classwork, Lab Materials, Videos etc.
21st Century Life and Careers	9.3.ST.2; 9.3.ST.ED.2; 9.3.ST-ET5

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Technology Standards	8.1.12.D.1; 8.2.12.E.1; 8.1.12.F.1		
Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**
Scaffolding Word Walls Sentence/paragraph frames Bilingual dictionaries/translation Think alouds Highlight key vocabulary Annotation guides Think-pair-share Visual aids Modeling See the Activity Handbook Multimedia Kahn Academy in native language (see topics in special education) See Fanelli for a copy of a Chemistry textbook, has both English and Spanish editions Flow Charts (Mini Guide to Problem Solving chapters 14, 15, 16, 17, 18, 20, 21, 22)	Word Walls chapter specific Visual Aids powerpoint, videos, demonstrations Graphic Organizers Multimedia Leveled readers Assistive technology Notes/summaries - share via powerpoint, handwritten, via cloud-based services (ex OneNote) Extended time Answer masking Answer eliminator Highlighter Color Contrast Teacher tutoring Peer tutoring Parent communication Modified assignments (provide formulas, use of calculator, provide data tables, exemplar samples of projects,, lower number of questions/simplify questions, etc) Counseling See the Activity Handbook Games (mole relay, stoichiometry relay, mole scavenger hunt, Kahoot, Jeopardy) Flow Charts (Mini Guide to Problem Solving chapters 14, 15, 16, 17, 18, 20, 21, 22)	Word Walls chapter specific Visual Aids powerpoint, videos, demonstrations Graphic Organizers Multimedia Leveled readers Assistive technology Notes/summaries - share via powerpoint, handwritten, via cloud-based services (ex OneNote) Extended time Answer masking Answer eliminator Highlighter Color Contrast Teacher tutoring Peer tutoring Parent communication Modified assignments (provide formulas, use of calculator, provide data tables, exemplar samples of projects,, lower number of questions/simplify questions, etc) Counseling See the Activity Handbook Games (mole relay, stoichiometry relay, mole scavenger hunt, Kahoot, Jeopardy) Flow Charts (Mini Guide to Problem Solving chapters 14, 15, 16, 17, 18, 20, 21, 22)	Curriculum compacting Challenge assignments Enrichment activities Tiered activities Independent research/Inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks Self-directed activities SAT II questions T/F/CE

	pHet labs - Molarity, Concentration, acid-base solutions, pH, sugar and salt solutions Online Calorimetry lab SAS V-Labs - acid base titrations, solution properties, gas laws, calorimetry, measures of concentration	pHet labs - Molarity, Concentration, acid-base solutions, pH, sugar and salt solutions Online Calorimetry lab SAS V-Labs - acid base titrations, solution properties, gas laws, calorimetry, measures of concentration	

Students who demonstrate understanding can:

HS-PS1-5. **Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.** [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [*Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.	**PS1.B: Chemical Reactions** • Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.	**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.

Connections to other DCIs in this grade-band:
HS.PS3.A

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS1.B** ; **MS.PS2.B** ; **MS.PS3.A** ; **MS.PS3.B**

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS1-5)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. *(HS-PS1-5)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS1-5)

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-PS1-5)*

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Students who demonstrate understanding can:

HS-PS1-6. **Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*** [Clarification Statement: Emphasis is on the application of Le Chatelier'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.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions

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

- Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

PS1.B: Chemical Reactions

- 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

- Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. *(secondary)*

Crosscutting Concepts

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

Connections to other DCIs in this grade-band:
HS.PS3.B

Articulation of DCIs across grade-bands:
MS.PS1.B

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Common Core State Standards Connections:
ELA/Literacy -

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-PS1-6)*

Students who demonstrate understanding can:

HS-ESS2-5. **Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.**[Clarification Statement: Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan 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.	**ESS2.C: The Roles of Water in Earth's Surface Processes** • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.	**Structure and Function** • 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.

Connections to other DCIs in this grade-band:
HS.PS1.A ; **HS.PS1.B** ; **HS.PS3.B** ; **HS.ESS3.C**

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS4.B** ; **MS.ESS2.A** ; **MS.ESS2.C** ; **MS.ESS2.D**

Common Core State Standards Connections:

ELA/Literacy -

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-ESS2-5)

Mathematics -

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-5)

Students who demonstrate understanding can:

HS-ESS3-5. **Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.** [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using computational models in order to make valid and reliable scientific claims. --- ***Connections to Nature of Science*** **Scientific Investigations Use a Variety of Methods** • Science investigations use diverse methods and do not always use the same set of procedures to obtain data. • New technologies advance scientific knowledge. **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence. • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS3.D: Global Climate Change** • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.	**Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.
Connections to other DCIs in this grade-band: ***HS.PS3.B*** ; ***HS.PS3.D*** ; ***HS.LS1.C*** ; ***HS.ESS2.D***		
Articulation of DCIs across grade-bands: ***MS.PS3.B*** ; ***MS.PS3.D*** ; ***MS.ESS2.A*** ; ***MS.ESS2.D*** ; ***MS.ESS3.B*** ; ***MS.ESS3.C*** ; ***MS.ESS3.D***		

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-5)
RST.11-12.2	Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. *(HS-ESS3-5)*
RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. *(HS-ESS3-5)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS3-5)
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-ESS3-5)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-5)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-5)

Students who demonstrate understanding can:

HS-ESS3-6. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.	**ESS2.D: Weather and Climate** • Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)* **ESS3.D: Global Climate Change** • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Systems and System Models** • 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.

Connections to other DCIs in this grade-band:
HS.LS2.B ; **HS.LS2.C** ; **HS.LS4.D** ; **HS.ESS2.A**

Articulation of DCIs across grade-bands:
MS.LS2.C ; **MS.ESS2.A** ; **MS.ESS2.C** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS3-6)
MP.4	Model with mathematics. (HS-ESS3-6)
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-ESS3-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-6)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-6)

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

5E Model	
Solutions and Equilibrium	
Engage Anticipatory Set	Prior Knowledge: Mole calculations (for concentration) Writing chemical equations Net ionic equations (honors level for solubility) Writing Compound Formulas (for acid-base reactions) Lab techniques Lewis structures Common Misconceptions: Solutions at equilibrium have no reaction occurring Molarity and percent are based on the solvent, rather than the whole solution Solvents must be liquid, solutes must be solid Lower pH is for weaker acids Acids have high pH values High exponents indicate stronger acidity/basicity Strong vs. Concentrated Acids "Like dissolves like" versus density
Exploration Student Inquiry	Constructing Explanations and Designing Solutions: ● Using lab data to describe rate law of equation Using Mathematics and Computational Thinking: ● Calculating rate orders for reactants by examining relationships between concentration and rate of overall reaction. ● Understanding exponential relationships of numbers. ● Analyzing and Interpreting Data ● Comparing before and after data to explain how system was affected by stress Constructing Explanations ● Students explain how an increase in carbon dioxide affects global weather patterns Planning and Carrying Out Investigations:

	• Students will plan an experiment that helps them discover which types of molecules attract each other. Planning and Carrying Out Investigations: • Lab Procedure to determine concentration of solution Constructing Explanations and Designing Solutions: • Students discuss how salt allowed ice cream to freeze. Planning and Carrying Out Investigations: • Students design experiment to determine base concentration through titration. Using Mathematics and Computational Thinking: • Students calculate concentration, pH, and ion concentrations.
Explanation Concepts and Practices	Solutions are made of a mixture of substances that are not chemically bound. Since collisions are required to cause a chemical reaction, increasing the number of collisions will increase the rate of reaction. Therefore, increasing the amount of reactants present or the temperature of the reactants increases the rate of reaction. Equilibrium can be shifted in response to certain changes to a system Le Chatelier's Principle describes the effects of changes to a system in equilibrium, based on the nature of the substances in the system Combustion of fuel has shifted the natural equilibrium of carbon dioxide in the atmosphere Water is polar. Molecules with similar intermolecular forces experience the strongest attractive forces to each other. Molarity is a way to quantify the amount of solute in a given volume of solution. Qualitatively, the words concentrated and dilute can be used to describe the amount of solute in a solution. The more solute in a solution, the higher the boiling point, lower the freezing point, and lower the vapor pressure. Osmotic pressure is a fourth property affected by amount of solute Acids and bases have unique properties that make them easily identifiable. Acids and bases are classified by Arrhenius and Bronsted-Lowry definitions The higher the hydrogen ion (hydronium) concentration, the lower the pH. pH is on a logarithmic scale.
Elaboration Extension Activity	NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation	**Potential Assessments:**

Assessment Tasks	• Interim mini-assessments • Inquiry Labs • See Chemistry Timeline for additional activities
Resources	http://www.chemistryland.com/CHM130FieldLab/Lab11/Lab11.html http://www.using-hydrogen-peroxide.com/elephant-toothpaste.html https://www.alkaseltzer.com/science-experiments/temperature/ The Andromeda Strain by Michael Crichton (book or movie selection) https://en.wikipedia.org/wiki/The_Andromeda_Strain_(film) Titration lab Le Chatelier Lab conceptual Le Chatelier Lab Freezing point depression Factors affecting Rate of Reaction Activity. polarity lab Freezing Point Depression and Boiling Point Elevation https://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/gc-swimming-pools.pdf http://genius.com/David-fincher-fight-club-chemical-burn-scene-annotated http://humantouchofchemistry.com/how-antacids-work.htm

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Unit 4: Overview
Unit 4: Energy
Content Area: Chemistry
Pacing: 5 Weeks (H); 5 weeks combined with unit 4 (CP)
Essential Questions
How can understanding energy changes help us to pick the best fuels? How does sunscreen protect against radiation? How much energy is released when food is burned in the body? How does the sun affect earth's climate?
Student Learning Objectives (Performance Expectations)
HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the process of fission, fusion, and radioactivity. HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. HS-PS3- 4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost- benefit ratios. HS- ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. HS-PS1- 4. Develop a model to illustrate the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
Unit Summary

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

By the end of this unit, students will know:

- The types of radiation (alpha, beta, gamma, positron, fission, fusion)
- How nuclear reactions show the law of conservation of mass
- How energy is stored in food

By the end of this unit, students will be able to:

- Write and balance nuclear equations
- Calculate half life
- Explain the difference between Calories and calories
- Calculate the energy in food
- Calculate the energy from a chemical reaction

Technical Terms

alpha/beta/gamma decay, positron emission, radioisotope, radioactivity, half-life, Calorie, calorie, Joule, endo/exothermic, Hess' Law, enthalpy, entropy, Gibb's free energy

Formative & Summative Assessment Measures

Potential Assessments:

- Interim mini-assessments
- Evaluation of car purchase (students are given three cars with different efficiency and fuel type, and determine which is the "best buy")
- Inquiry Labs
- See Chemistry Timeline for additional activities

Interdisciplinary Connections

NJSLS- ELA	NJSLS- Mathematics
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-PS3-4), (HS-ESS1-1)(HS- ESS3-2)(HS-ESS3-4) 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	MP.2 Reason abstractly and quantitatively. (HS-PS3-1), (HS-PS3-4), (HS-ESS1-1), (HS-ESS2-4), (HS-ESS3-2), (HS-ESS3-6), (HS-ESS3-4) MP.4 Model with mathematics. (HS-PS3-1), (HS-PS3-4), (HS-ESS1-1), (HS-ESS2-4), (HS-ESS3-6), (HS-PS1-4) HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-8), (HS-PS3-1),

sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS3-4) 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 over-reliance on any one source and following a standard format for citation. (HS-PS3-4) WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4) 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-PS3-1), (HS-ESS2-4)(HS-PS1-4) RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2)(HS-ESS3-4)	(HS-ESS1-1), (HS-ESS2-4), (HS-ESS3-6), HS-PS1-4), (HS-ESS3-4) HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-8), (HS-PS3-1), (HS-ESS1-1), (HS-ESS2-4), (HS-ESS3-6), (HS-PS1-4), HS-ESS3-4) HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS1-8), (HS-PS3-1), (HS-ESS1-1), (HS-ESS2-4), (HS-ESS3-6), (HS-PS1-4), HS-ESS3-4) HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-ESS1-1) HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HSESS1-1) HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-ESS1-1) 21st Century Skills- **9.2.12.C.1** Review career goals and determine steps necessary for attainment. **9.2.12.C.3** Identify transferable career skills and design alternate career plans. **9.1.12.A.3** Analyze the relationship between various careers and personal earning goals **9.1.12.A.4** Identify a career goal and develop a plan and timetable for achieving it, including educational/training requirements, costs, and possible debt **9.1.12.A.5** Analyze how the economic, social, and political conditions of a time period can affect the labor market.
Core Instructional Materials	Can include: NJCTL Presentations/Classwork, Lab Materials, etc.
21st Century Life and Careers	9.3.ST.2; 9.3.ST.ED.2; 9.3.ST-ET5
Technology Standards	8.1.12.D.1; 8.2.12.E.1; 8.1.12.F.1

Modifications			
English Language Learners	**Special Education**	**At-Risk**	**Gifted and Talented**

Scaffolding Word Walls Sentence/paragraph frames Bilingual dictionaries/translation Think alouds Highlight key vocabulary Annotation guides Think-pair-share Visual aids Modeling See the Activity Handbook Peer tutoring - classmate that understands native language Multimedia Kahn Academy in native language (topics see special education) See Fanelli for a copy of a Chemistry textbook, has both English and Spanish editions Flow Charts (Mini Guide to Problem Solving chapters 19)	Word Walls chapter specific Visual Aids powerpoint, videos, demonstrations Graphic Organizers Multimedia Leveled readers Assistive technology Notes/summaries - - share via powerpoint, handwritten, via cloud-based services (ex OneNote) Extended time Answer masking Answer eliminator Highlighter Color Contrast Teacher tutoring Peer tutoring - H student or classmate Parent communication Modified assignments (provide formulas, use of calculator, provide data tables, exemplar samples of projects,, lower number of questions/simplify questions, etc) Counseling See the Activity Handbook Games (whiteboard races, Kahoot, Jeopardy) Flow Charts (Mini Guide to Problem Solving chapters 19) pHet labs - alpha decay, beta decay, fission, radioactive dating	Word Walls chapter specific Visual Aids powerpoint, videos, demonstrations Graphic Organizers Multimedia Leveled readers Assistive technology Notes/summaries - - share via powerpoint, handwritten, via cloud-based services (ex OneNote) Extended time Answer masking Answer eliminator Highlighter Color Contrast Teacher tutoring Peer tutoring - H student or classmate Parent communication Modified assignments (provide formulas, use of calculator, provide data tables, exemplar samples of projects,, lower number of questions/simplify questions, etc) Counseling See the Activity Handbook Games (whiteboard races, Kahoot, Jeopardy) Flow Charts (Mini Guide to Problem Solving chapters 19) pHet labs - alpha decay, beta decay, fission, radioactive dating	Curriculum compacting Challenge assignments Enrichment activities Tiered activities Independent research/Inquiry Collaborative teamwork Higher level questioning Critical/Analytical thinking tasks Self-directed activities SAT II questions T/F/CE

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Students who demonstrate understanding can:

HS-PS1-4. **Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.** [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [*Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Developing and Using Models

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

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system.

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- 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.

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

Crosscutting Concepts

Energy and Matter

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Connections to other DCIs in this grade-band:
HS.PS3.A ; **HS.PS3.B** ; **HS.PS3.D** ; **HS.LS1.C**

Articulation of DCIs across grade-bands:
MS.PS1.A ; **MS.PS1.B** ; **MS.PS2.B** ; **MS.PS3.D** ; **MS.LS1.C**

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Common Core State Standards Connections:

ELA/Literacy -

SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. *(HS-PS1-4)*

Mathematics -

MP.4 Model with mathematics. *(HS-PS1-4)*

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-PS1-4)*

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-4)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-4)*

Students who demonstrate understanding can:

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

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**PS1.C: Nuclear Processes** • Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**Energy and Matter** • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

Connections to other DCIs in this grade-band:
HS.PS3.A ; ***HS.PS3.B*** ; ***HS.PS3.C*** ; ***HS.PS3.D*** ; ***HS.ESS1.A*** ; ***HS.ESS1.C***

Articulation of DCIs across grade-bands:
MS.PS1.A ; ***MS.PS1.B*** ; ***MS.ESS2.A***

Common Core State Standards Connections:
Mathematics -

MP.4 Model with mathematics. *(HS-PS1-8)*

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-PS1-8)

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-8)

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-8)*

Students who demonstrate understanding can:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

HS-PS3-1	**Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.** [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [*Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices

Using Mathematics and Computational Thinking

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

- Create a computational model or simulation of a phenomenon, designed device, process, or system.

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.

PS3.B: Conservation of Energy and Energy Transfer

- Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.
- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.
- The availability of energy limits what can occur in any system.

Crosscutting Concepts

Systems and System Models

- Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.

Connections to Nature of Science

Scientific Knowledge Assumes an Order and Consistency in Natural Systems

- Science assumes the universe is a vast single system in which basic laws are consistent.

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Connections to other DCIs in this grade-band:
HS.PS1.B ; ***HS.LS2.B*** ; ***HS.ESS1.A*** ; ***HS.ESS2.A***

Articulation of DCIs across grade-bands:
MS.PS3.A ; ***MS.PS3.B*** ;***MS.ESS2.A***

Common Core State Standards Connections:

ELA/Literacy -

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-PS3-1)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS3-1)

MP.4 Model with mathematics. (HS-PS3-1)

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-PS3-1)

HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1)

HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1)

Students who demonstrate understanding can:

HS-PS3-4. **Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).** [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [*Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**PS3.B: Conservation of Energy and Energy Transfer** • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. • Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	**Systems and System Models** • 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.

Connections to other DCIs in this grade-band:
HS.ESS1.A ; ***HS.ESS2.A*** ; ***HS.ESS2.D***

Articulation of DCIs across grade-bands:
MS.PS3.B

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. *(HS-PS3-4)*

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-PS3-4)

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-PS3-4)

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS3-4)*

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-PS3-4)

MP.4	Model with mathematics. *(HS-PS3-4)*

Students who demonstrate understanding can:

HS-ESS2-4. **Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** [Clarification Statement: Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition.] [*Assessment Boundary: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Use a model to provide mechanistic accounts of phenomena. - ***Connections to Nature of Science*** **Scientific Knowledge is Based on Empirical Evidence** • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**ESS1.B: Earth and the Solar System** • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary)* **ESS2.A: Earth Materials and Systems** • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.	**Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Connections to other DCIs in this grade-band:
HS.PS3.A ; **HS.PS3.B** ; **HS.LS2.C** ; **HS.ESS1.C** ; **HS.ESS3.C** ; **HS.ESS3.D**

Articulation of DCIs across grade-bands:
MS.PS3.A ; **MS.PS3.B** ; **MS.PS3.D** ; **MS.PS4.B** ; **MS.LS1.C** ; **MS.LS2.B** ; **MS.LS2.C** ; **MS.ESS2.A** ; **MS.ESS2.B** ; **MS.ESS2.C** ; **MS.ESS2.D** ; **MS.ESS3.C** ; **MS.ESS3.D**

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Common Core State Standards Connections:

ELA/Literacy -

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-ESS2-4)*

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS2-4)
MP.4	Model with mathematics. (HS-ESS2-4)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-ESS2-4)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS2-4)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS2-4)

Students who demonstrate understanding can:

HS-ESS3-2. **Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*** [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence 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. • Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	**ESS3.A: Natural Resources** • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. *(secondary)*	***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. • Analysis of costs and benefits is a critical aspect of decisions about technology. ***Connections to Nature of Science*** **Science Addresses Questions About the Natural and Material World** • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. • 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. • Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.

Connections to other DCIs in this grade-band:
HS.PS3.B ; **HS.PS3.D** ; **HS.LS2.A** ; **HS.LS2.B** ; **HS.LS4.D** ; **HS.ESS2.A**

Articulation of DCIs across grade-bands:
MS.PS3.D ; **MS.LS2.A** ; **MS.LS2.B** ; **MS.LS4.D** ; **MS.ESS3.A** ; **MS.ESS3.C**

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Common Core State Standards Connections:

ELA/Literacy -

RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-ESS3-2)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ESS3-2)

Mathematics -

MP.2 Reason abstractly and quantitatively. (HS-ESS3-2)

Students who demonstrate understanding can:

HS-ESS3-6. **Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** [Clarification Statement: Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.] [*Assessment Boundary: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.*]

The performance expectation above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.	**ESS2.D: Weather and Climate** • Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)* **ESS3.D: Global Climate Change** • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Systems and System Models** • 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.

Connections to other DCIs in this grade-band:
HS.LS2.B ; **HS.LS2.C** ; **HS.LS4.D** ; **HS.ESS2.A**

Articulation of DCIs across grade-bands:
MS.LS2.C ; **MS.ESS2.A** ; **MS.ESS2.C** ; **MS.ESS3.C** ; **MS.ESS3.D**

Common Core State Standards Connections:
Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS3-6)
MP.4	Model with mathematics. (HS-ESS3-6)
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-ESS3-6)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. *(HS-ESS3-6)*
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-ESS3-6)

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018

5E Model	
HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the process of fission, fusion, and radioactivity. HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. HS-PS3- 4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost- benefit ratios. HS- ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. HS-PS1- 4. Develop a model to illustrate the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	
Engage Anticipatory Set	Prior Knowledge: ● Students need to know how find how many protons and neutrons are in the nucleus of an atom. ● Students need to know how to take accurate measurements of mass and temperature. ● Students will need to know about particle movement within a given state of matter to draw connections to energy content and movement. ● Students need to know how to balance equations. ● Students need to know law of conservation of mass. ● Students need to be able to differentiate mass and energy as well as be able to identify different types of energy. Common Misconceptions: ● Endothermic reactions feel hot and exothermic reactions feel cold ● All radiation is bad for humans ● All objects heat/cool at the same rate

	• Calorie vs calorie • Confusion of Heat capacity (c) and heat (q) • Climate change versus global warming. Belief that it's just causing world to get hotter.
Exploration Student Inquiry	Developing and Using Models: • Students can use pennies or candies to represent atoms or subatomic particles while discussing half life or radioactive decay. Planning and Carrying Out Investigations: • Students will design a lab regarding food calorimetry. They will select the foods to burn and design a device to prevent heat loss during the experiment. Engaging in Argument from Evidence: • Students will use data from the lab to determine the best type of food to select for a snack. Conservation of Energy and Energy Transfer: • Students will evaluate the energy transfer in their experiment to determine efficiency and deficits in their procedure Conservation of Energy and Energy Transfer: • Students will graph the temperature changes during the aluminum foil heat lab to show the heat flow during the reaction. Energy in Chemical Processes: • Students will compare the energy used to decompose the oxygen in the gummy bear demo to the energy released by the combustion of the gummy bear. Analyzing and Interpreting Data • Students interpret data to consider impact of different fuel sources Engaging in Argument from Evidence • Students argue whether diesel or gas is a better fuel source based on research Using Mathematics and Computational Thinking: • Students will perform calculations to show the efficiency of different fuels and their production of heat. • Students will perform calculations to determine how much carbon is generated from each type of fuel.
Explanation Concepts and Practices	Radiation particles break off of an unstable nucleus. Nuclei are unstable when the number of protons and neutrons are out of balance (1:1 not necessary for atoms over #20) When an atom loses a radiation particle it transforms into a different atom because the number of protons changes. Radiation particles can be detected using a tool called a geiger counter.

	Nuclear radiation and electromagnetic radiation are different concepts. Heat is a transfer of energy. Heat lost by one object is gained by another.(or in some cases multiple objects) Specific heat capacity describes how easily an object gains or loses heat. Heat generated by humans through daily activities gets transferred to the atmosphere/ surrounding area. Heat is a common reactant/product of chemical reactions Energy is needed to start reactions and separate atoms Exothermic reactions release energy, endothermic reactions gain energy Different fuels release different amounts of energy Burning hydrocarbons releases carbon dioxide, which traps heat in Earth's atmosphere Different hydrocarbons/fuels create varying amounts of carbon dioxide Efficiency of a system varies based on the conditions in which it exists in.
Elaboration Extension Activity	NEWSELA articles (or other appropriate articles) should be used to enhance literacy skills of students and reinforce content vocabulary.
Evaluation Assessment Tasks	**Potential Assessments:** ● Interim mini-assessments ● Evaluation of car purchase (students are given three cars with different efficiency and fuel type, and determine which is the "best buy") ● Inquiry Labs ● See Chemistry Timeline for additional activities
Resources	http://pono.ucsd.edu/~adam/wordpress/beachphysics/files/2013/12/BlackPaperLabPortrait.pdf http://www2.vernier.com/sample_labs/ESV-21-COMP-comparing_sunscreens.pdf https://www.youtube.com/watch?v=5oUagoF_viQ https://www.youtube.com/watch?v=siIfGK4iwUw Myers, Oldham, Tocci. CHEMISTRY, Austin, Tx; Holt, Rinehart and Winston, 2006.

SUBJECT: SCIENCE/Chemistry

Cliffside Park Public Schools

GRADE: 9-12

BOE APPROVAL: 8/2018