*Unit 5. Solutions & Acids & Bases

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Unit Summary

Most everyday matter occurs as mixtures- combinations of two or more substances. Mixtures can be separated by physical means. Common separation techniques include filtration, distillation, and chromatography. Mixtures can be either heterogeneous or homogeneous. Concentration can be expressed in terms of percent (by mass or volume) or in terms of moles (Molarity, molality, and mole fraction). Factors such as temperature, pressure, and polarity affect the formation of solutions. Colligative properties depend on the number of solute particles in a solution (freezing point depression and boiling point elevation)

Acids and bases have real life significance. The human body functions properly only when delicate acid base balances are maintained, crops grow best in soil with proper pH, substances released into the atmosphere as pollutants form acid rain and foods as well as many substances used in the home are acids and bases. This unit focuses on the structure, properties and reactions of acids and bases. Acids and bases are a specific class of molecules which needs to be distinguished by strong acids and bases versus weak acids and bases. Also can be described based on the degree of ionization of the molecules which can be used to calculate the pH, pOH, [H+] and [OH-]. The pH scale shows the degree of ionization. Descriptions of acids and bases fall in three categories: Arrhenius, Brønsted-Lowery, and Lewis. Neutralization reactions are used in titrations to identify concentrations of unknown acids and bases.

Enduring Understandings

1. The properties of elements determine how atoms and molecules interact.
2. Forces attract, hold together, or repel matter.

Essential Questions

1. How does the amount of solute present affect the properties of a solution?
2. How is each type of concentration calculated?
3. What is the reason for the change in boiling point, freezing point, or vapor pressure of a solvent, to which has been added a nonvolatile solute.
4. What factors affect the solubility of a solute in a solvent? (temperature, pressure, nature of solute)
5. How does the amount of solute vary in a saturated, unsaturated, and supersaturated solution?

6. What are acids and bases?
7. What are some properties of acids and bases?
8. What is pH and how does it measure the concentration of acids and bases?
9. How do acids and bases react with each other?

Student Learning Objectives (PE, SEP, DCI, CCC) & Aligned Standards

Performance Expecations

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

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

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

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

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

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 studentgenerated sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5)
- Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3)

Developing and Using Models

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

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-8)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

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 tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS1-3)
- Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data. (HS-PS1-3)

Using Mathematics and Computational Thinking

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

- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

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. (HS-PS1-2)

· The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-2)

·The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3)

- **PS1.B: Chemical Reactions**

  ·Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-5)

  ·The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7)

- **PS2.B: Types of Interactions**

  ·Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.(secondary to HS-PS1-1),(secondary to HS-PS1-3)

  ETS1.B: Developing Possible Solutions

  When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)

  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. (HS-ETS1-3)

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. (HS-PS1-2, HS-PS1-3, HS-PS1-5)

Energy and Matter

In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

(HS-PS1-7)

Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales(HS-PS1-3)

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Literacy Standards

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-PS1-2)

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,HS-PS1-5)

RST.11-12.3:Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text

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-ETS1-3)

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-ETS1-3)

RST.11-12.9: Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3)

WHST.9-12.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes. (HS-PS1-2) (HS-PS1-5)

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

WHST.9-12.8: 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: evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3)

Concepts & Skills

Concepts and Skills:

Mixtures:

- compare and contrast homogeneous and heterogeneous mixtures.
- explain the 3 techniques on how to separate a mixture (filtration, chromatography, and distillation).
- understand that separating pure substances from mixtures is a physical change and may require energy.
- understand the differences between mixtures and pure substances.

Solutions:

- define and apply the terms solution, aqueous solution, solute, and solvent.
- list and explain the factors that affect the rate of dissolving
- understand how the concentration of a solution may be quantitatively described (Molarity, molality, mole fraction, % by mass, % by volume).
- use the concept of “like dissolves like” to predict the solubility of one substance in another.
- describe the procedure for preparing a dilute solution of a known concentration from a more concentrated solution.
- use colligative properties to predict boiling points or freezing points of given solutions.

- distinguish among weak electrolytes, strong electrolytes, and nonelectrolytes (ionic vs. covalent).
- distinguish between saturated, unsaturated, and supersaturated solutions.
- understand how the temperature and pressure affect the solubility of the solute.
- use Henry's Law to describe the relationship between pressure and solubility in a gaseous solution.
- interpret a solubility curve.
- explain the process of solvation.
- describe and calculate the change in vapor pressure of a solution
- describe and calculate the boiling point elevation and freezing point depression of a solution.

Acids/Bases

- Define acids and bases operationally and also conceptually (using modern theories.)
- Distinguish between forms of acids and bases using their properties.
- Determine whether a solution is acidic or basic using an indicator or pH meter.
- Interpret pH in terms of powers of ten.
- Compare the strengths of acids and bases and apply these concepts to buffer solutions.
- Be able to complete an acid base neutralization reaction given the identities of the reacting acids and bases.
- Complete an acid base titration and use the concept of molarity to determine the concentration of a titration reaction.
- explore the roles of acids and bases in the world

Vocabulary:

Homogeneous mixture, heterogeneous mixture, mixture, chromatography, distillation, filtration, crystallization, solution, immiscible, miscible, soluble, insoluble, concentration, Molarity, molality, mole fraction, Henry's Law, saturated solution, unsaturated solution, supersaturated solution, solvation, boiling point elevation, colligative property, freezing point depression, vapor pressure lowering, solute, solvent, Acid/Base neutralization reaction, Strong/weak Acid, Brønsted-Lowry acid & base, Arrhenius acid & base,Strong/weak base, pH, Alkaline, salt, Amphoteric, titration, Buffer, indicator, End point, Equivalence point, Hydronium ion, Lewis/acid & base

Resources

Links to Free and Low Cost Instructional Resources

Note- *The majority ofthe student sense-making experiences found at these links predate the NGSS. Most will need to be modified to include science and engineering practices, disciplinary core ideas, and cross cutting concepts. The EQuIP Rubrics for Science can be used as a blueprint for evaluating and modifying instructional materials.*

- American Association for the Advancement of Science: *http://www.aaas.org/programs*
- American Chemical Society: *http://www.acs.org/content/acs/en/education.html*
- Concord Consortium: Virtual Simulations: *http://concord.org/*
- International Technology and Engineering Educators Association: *http://www.iteaconnect.org/*
- National Earth Science Teachers Association: *http://www.nestanet.org/php/index.php*
- National Science Digital Library: *https://nsdl.oercommons.org/*
- National Science Teachers Association: http://ngss.nsta.org/Classroom-Resources.aspx
- North American Association for Environmental Education: *http://www.naaee.net/*
- Phet: Interactive Simulations *https://phet.colorado.edu/*
- *Science NetLinks: http://www.aaas.org/program/science-netlinks*

Assessments

Possible Assessment Tasks:

- Practice Worksheets for each section
- Separations of Mixtures: on-line simulations: http://www.fossweb.com/delegate/ssi-foss-ucm/Contribution%20Folders/FOSS/multimedia/Mixtures_and_Solutions/separatingmixtures/index.html or http://www.mheducation.ca/school/applets/bcscience7/mixtures/bcscience7_mixtures.swf
- Lab: Separations of Mixtures
- Explore Concentration (phet on-line simulation HTML5) https://phet.colorado.edu/en/simulation/concentration
- Salts & Solubility (phet online simulation-Java) https://phet.colorado.edu/en/simulation/legacy/soluble-salts
- Sugar and Salt Solutions (phet online simulation-

Java) https://phet.colorado.edu/en/simulation/legacy/sugar-and-salt-solutions

- Molarity (phet onine simulation- HLTM5) https://phet.colorado.edu/en/simulation/molarity
- Lab: How much does it cost to de-ice our roads?
- Acid Base Solutions (phet online simulation- HTML5) https://phet.colorado.edu/en/simulation/acid-base-solutions
- pH scale (phet online simulation- HTML5) https://phet.colorado.edu/en/simulation/ph-scale or BASIC https://phet.colorado.edu/en/simulation/ph-scale-basics
- Lab: Acid Base Titration

The Science Classroom

This unit of study continues looking at energy flow and matter but with a new emphasis on Earth and space science in relation to the history of Earth starting with the Big Bang theory. Students will also explore the production of elements in stars and radioactive decay. Students should develop and use models to illustrate the processes of fission, fusion, and radioactive decay and the scale of energy released in nuclear processes relative to other kinds of transformations, such as chemical reactions. Models should be qualitative, based on evidence, and might include depictions of radioactive decay series such as Uranium-238, chain reactions such as the fission of Uranium-235 in reactors, and fusion within the core of stars. Students could also explore the PhET nuclear fission inquiry lab and graphs to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of alpha, beta, and gamma radioactive decays. When modeling nuclear processes, students should depict that atoms are not conserved, but the total number of protons plus neutrons is conserved. Models should include changes in the composition of the nucleus of atoms and the scale of energy released in nuclear processes.

The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. Other than hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. Because atoms of each element emit and absorb characteristic frequencies of light, the presence of an element can be detected in stars and interstellar gases. Students should develop an understanding of how analysis of light spectra gives us information about the composition of stars and interstellar gases. Communication of scientific ideas about how stars produce elements should be done in multiple formats, including orally, graphically, textually, and mathematically. The conservation of the total number of protons plus neutrons is important in their explanations, and students should cite supporting evidence from text.

Students should also use the sun as a model for the lifecycle of a star. This model should also illustrate the relationship between nuclear fusion in the sun's core and energy that reaches the Earth in the form of radiation. Students could construct a mathematical model of nuclear fusion in the sun's core, identifying important quantities and factors that affect the life span of the sun. They should also be able to use units and consider limitations on measurement when describing energy from nuclear fusion in the sun's core that reaches the Earth. For example, students should be able to quantify the amounts of energy in joules when comparing energy sources. In this way, students will develop an understanding of how our sun changes and how it will burn out over a lifespan of approximately 10 billion years.

This unit continues with a study of how astronomical evidence ("red shift/blue shift," wavelength relationships to energy, and universe expansion) can be used to support the Big Bang theory. Students should construct an explanation of the Big Bang theory based on evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. Students should explore and cite evidence from text of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of primordial radiation that still fills the universe. The concept of conservation of energy should be evident in student explanations. Students should also be aware that 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. Students should also know that if new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of the new evidence.

Students should be able to cite specific evidence from text to support their explanations of the life cycle of stars, the role of nuclear fusion in the sun's core, and the Big Bang theory. In their explanations, they should discuss the idea that science assumes the universe is a vast single system in which laws are consistent.

This unit concludes with the application of scientific reasoning and the use of evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of the Earth's formation and early history. For example, students will use examples of spontaneous radioactive decay as a tool to determine the ages of rocks or other materials (K-39 to Ar-40). Students should make claims about Earth's formation and early history supported by data while considering appropriate units, quantities and limitations on measurement. Students might construct graphs showing data on the absolute ages and composition of Earth's rocks, lunar rocks, and meteorites. Using available evidence within the solar system, students should construct explanations for how the earth has changed and how it has remained stable in its 4.6 billion year history.

Connecting with English Language Arts Literacy and Mathematics

See aligned standards.

Modifications

Teacher Note: Teachers identify the modifications that they will use in the unit. The unneeded modifications can then be deleted from the list.

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

Research on Student Learning

N/A

Prior Learning

Physical science

- Substances are made from different types of atoms, which combine with one another in various ways.

Atoms form molecules that range in size from two to thousands of atoms.

- Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).
- The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter.
- Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.
- The total number of each type of atom is conserved, and thus the mass does not change.
- Some chemical reactions release energy, others store energy.
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.
- A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media.
- However, because light can travel through space, it cannot be a matter wave, like sound or water waves.

Earth and space science

- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models.
- Earth and its solar system are part of the Milky Way Galaxy, which is one of many galaxies in the universe.
- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms.
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future.
- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.
- Because these patterns are so complex, weather can only be predicted probabilistically.
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents.

Connections to Other Courses

Physical science

- 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 elements with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.
- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.
- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.
- 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 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.
- 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.
- 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).
- When two objects interacting through a field change relative position, the energy stored in the field is changed.
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.
- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.
- When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.
- Photoelectric materials emit electrons when they absorb light of a high-enough frequency.

Earth and space science

- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars

produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.
- Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.
- 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.

References

Adapted from the New Jesery NGSS Science Model Curriclum

Connections to NJSJS

English Language Arts/Literacy -

RST.11-12.1	Cite specific textual evidence to support analysis of science and technical texts, attending to impor makes and to any gaps or inconsistencies in the account. (HS-ESS1-1)
WHST.9-12.2	Write informative/explanatory texts, including the narration of historical events, scientific procedu technical processes. (HS-ESS1-3),(HS-ESS1-2)
SL.11-12.4	Present claims and findings, emphasizing salient points in a focused, coherent manner with releva reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronu

Mathematics -

MP.2	Reason abstractly and quantitatively. (HS-ESS1-1), (HS-ESS1-2) ,(HS-ESS1-3) ,(HS-PS1-8)
MP.4	Model with mathematics. (HS-ESS1-1)
HSN-Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choos consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. 2)
HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-ESS1-1), (HS-ESS1-2
HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (
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 equ with labels and scales. (HS-ESS1-1), (HS-ESS1-2)
HSA-CED.A.4	Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equa ESS1-2)