*Unit 4. Energy, Change & States of Matter

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Unit Summary

Chemical reactions usually absorb or release energy. Energy can change form and flow, but it is always conserved. The enthalpy change for a reaction is the enthalpy of the product minus the enthalpy of the reactants. Thermochemical equations express the amount of heat released or absorbed by chemical reactions. Gases expand, diffuse, exert pressure, and can be compressed because they are in a low-density state consisting of tiny, constantly-moving particles. The particles in solids and liquids have a limited range of motion and are not easily compressed. Intermolecular forces (dispersion, dipole-dipole, hydrogen bonds) determine a substance's state at a given temperature. Matter changes phases when energy is added or removed or when pressure changes occur. For a fixed amount of gas, a change in one variable (pressure, temperature, or volume) affects the other two. The ideal gas law relates the number of particles to pressure, temperature and volume. When gases react, the coefficients in the balanced chemical equation represent both molar amounts and relative volumes.

Enduring Understandings

1. Energy is neither created nor destroyed.
2. Forces attract, hold together, or repel matter.

Essential Questions

1. How can you support the law of conservation of mass using a chemical equation?
2. How is the enthalpy of a reaction calculated?
3. What is the relationship between the bond energy between atoms and the bond enthalpy of a molecule?
4. How can the bond energy between atoms be used to prove that energy is neither created nor destroyed in a chemical reaction?
5. How do you qualitatively interpret a heating curve in terms of kinetic and potential energy and phase changes?
6. What are the differences between an exothermic reaction and an endothermic reaction?
7. How can you summarize the difference in the particle arrangement and average particle energy among

particles in the solid, liquid, or gaseous form of a substance?

8. How do intermolecular forces between particles explain the bulk properties of substances?
9. How do intermolecular forces of attraction affect the rate of evaporation, boiling point and melting point of a liquid?
10. How does Kinetic Molecular Theory predict the relationship between particles of a gas, and in turn the behavior of a gas?
11. How is Graham's Law related to the average kinetic energy of particles of a gas?
12. What are the factors that determine which gas law to use, to solve word problems?
13. What label(s) is (are) appropriate for each parameter for each gas law?
14. Under what conditions will a real gas deviate from an ideal gas (or, the Ideal Gas Law)?

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

HS-PS1-7: 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 problemsolving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

HS-PS3-4: **Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more**

uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]

HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards and changes in climate have influenced human activity.

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.

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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. (HS-PS1-4)
- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-4)

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-PS1-7, HS-PS3-4)

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

- 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)
- A stable molecule has less energy than the same set of atoms separated; one mist provide at least this energy in order to take the molecule apart (HS-PS1-4)

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4)
- 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)

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.,(HS-PS3-4)
- 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). (HS-PS3-4)

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. (HS-PS3-4)

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)

Energy and Matter

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-7, HS-PS1-4)

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. (HS-PS3-4)

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-PS1-4)

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

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

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)

Concepts & Skills

Concepts and Skills:

- identify a reaction as endothermic or exothermic depending upon the location of the energy term in the chemical equation.(revisted after equilibrium)
- identify a reaction as exothermic or endothermic when given a value of change in enthalpy (delta H).
- understand that all chemical reactions either produce energy (exothermic) or absorb energy (endothermic) as a result of the breaking and making of chemical bonds.
- use the equation q = mc(Tf-Ti) to calculate the heat, mass, specific heat, or change in temperature of a substance when given the other three variables.
- determine if the reaction is endothermic or exothermic based on the sign (+/-) of “q”.
- explain how a calorimeter is used to measure the specific heat of a metal.
- predict if the energy is flowing from system to surroundings (exothermic) or surroundings to system (endothermic).
- distinguish relative strengths of intermolecular forces (do not identify types) based upon observable properties (i.e. rates of evaporation, m.p., or b.p.).
- explain how the addition and removal of energy can cause a phase change.
- describe the changes in kinetic (thermal) and potential energy that occur along various parts of the heating curve and/or phase diagram.

- distinguish between vaporization, boiling, and evaporation.
- predict the response of a gas to changes in pressure, volume, or temperature, using the appropriate gas law.
- understand and use the ideal gas law to solve word problems.
- explain the difference between an ideal gas and a real gas.
- explain the difference between heat and temperature
- convert between the various units of pressure (atm, kPa, Pa, mmHg, psi)

Vocabulary:

chemical potential energy, energy, heat, joule, law of conservation of energy, specific heat, calorimeter, enthalpy, enthalpy heat of reaction, surroundings, system, thermochemistry, universe, endothermic, exothermic, Hess's law, heating curve, enthalpy (heat) of combustion, enthalpy (heat) of fusion, enthalpy (heat) of vaporization, thermochemical equation, standard enthalpy (heat) of formation , Barometer, Dalton's Law of Partial Pressures, diffusion, elastic collisions, Graham's Law of Effusion, effusion, kinetic-molecular theory, pressure, temperature, boiling point, condensation, deposition, evaporation, freezing point, melting point, phase diagram, triple point, critical point, vaporization, vapor pressure, absolute zero, Boyle's Law, Charles' Law, Gay-Lussac's Law, Combined Gas Law, ideal gas constant, ideal gas law, molar volume (22.4L/mole)

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*

- Greenhouse Gases and Climate Change Data Analysis Virtual Lab: Link 1, Link 2, Link 3, Link 4, Link 5, Link 6, Link 7

Assessments

Possible Assessment Tasks:

- Practice Worksheets for each section
- Lab: Specific Heat of metals
- Lab: Calorimetry
- Lab: heating and cooling curves
- Bond Enthalpy: on-line simulation: http://www.avogadro.co.uk/h_and_s/bondenthalpy/bondenthalpy.htm
- Explore States of Matter- (phet on-line simulation) https://phet.colorado.edu/en/simulation/legacy/states-of-matter or basic https://phet.colorado.edu/en/simulation/legacy/states-of-matter-basics
- Explore Gas Variables (phet on-line simulation- Java) https://phet.colorado.edu/en/simulation/legacy/gas-properties
- Lab: Gas Laws

The Science Classroom

This unit of study continues to build on the concept of energy flow and matter discussed in units 1, 2, and 3; however it approaches the content from a life science standpoint. Students use their understanding of energy flow and conservation of energy to support their learning as they model photosynthesis and cellular respiration. Previous work with chemical reactions will help students develop explanations for the formation of amino acids and other large, carbon-based molecules. Also, students continue developing and using models, constructing explanations and designing solutions, and obtaining, evaluating, and communicating information.

This unit of study continues looking at energy flow and matter but with emphasis on photosynthesis, cellular respiration, and polymerization. Students should use models such as diagrams, chemical equations, and conceptual models to illustrate how matter and energy flow through different organizational levels of living systems, from microscale to macroscale.

In particular, both photosynthesis and cellular respiration will be the reactions used to emphasize that the reactants (inputs) and products (outputs) show the transfer of matter and energy from one system of interacting molecules to another. In developing models to represent how photosynthesis transforms light energy into stored chemical energy and the inputs and outputs of cellular respiration, students might use digital media in presentations to enhance understanding. *[Clarification, The focus of this unit is on the basic inputs and outputs of these processes. The specific biological steps of the Calvin cycle, Glycolysis, and Kreb cycle are not the focus this unit]*. Developing an understanding of photosynthesis and respiration will allow students to model radiant energy transferred from a macrosystem, such as the ocean, to a microsystem, such as an individual organism like plankton. In photosynthesis, light energy is converted to stored energy when carbon dioxide and water are converted into sugars. Oxygen is released in this process. The organism then converts the chemical energy into a usable form (A.T.P) on the cellular level through the process of cellular respiration. This process gives organisms the energy needed to maintain life functions. An example is how some organisms need energy to maintain body temperature despite ongoing energy transfer to the surrounding environment.

Models should use evidence to illustrate how photosynthesis transforms light energy into stored chemical energy; how cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed, resulting in a net transfer of energy; and to illustrate the inputs and outputs of matter and the transformations of energy in both processes. Models could include chemical equations, flow diagrams, manipulatives, and conceptual models. Models should also illustrate that energy cannot be created or destroyed, and that it moves only between one place and another, between objects, or between systems.

At the same time, students take an in-depth look at the polymerization of sugar; they should research and investigate how simple sugars (made from carbon, hydrogen, and oxygen) are combined and recombined in different structures with specific functions. Students will construct and revise explanations for how simple sugars help form hydrocarbon backbones (amino acids) or carbon-based backbones (protein, DNA, new organism). Explanations should be supported and revised using evidence from multiple sources of text, models, theories, simulations, students' own investigations, and peer review. Students' explanations should describe the formation of amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA) that can be used, for example, to form new cells. It is important to remember that students are only required to conceptually understand the process, not the specific chemical reactions or the identification of macromolecules such as amino acids and DNA.

Connecting with English Language Arts Literacy and Mathematics

English Language Arts/Literacy

- Make strategic use of digital media in presentations to enhance understanding of how photosynthesis transforms light energy into stored chemical energy.
- Use digital media in presentations to enhance understanding of the inputs and outputs of the process of cellular respiration.
- Cite specific textual evidence to support how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.
- Use evidence from multiple sources to clearly communicate an explanation for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.
- Revise an explanation for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant.
- Draw evidence from informational texts to describe how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large, carbon-based molecules.

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

Students' meaning for “energy” both before and after traditional instruction is considerably different from its scientific meaning. In particular, students believe energy is associated only with humans or movement, is a fuel-like quantity which is used up, or is something that makes things happen and is expended in the process. Students rarely think energy is measurable and quantifiable.

Students tend to think that energy transformations involve only one form of energy at a time. Although they develop some skill in identifying different forms of energy, in most cases their descriptions of energy change focus only on forms that have perceivable effects. The transformation of motion to heat seems to be difficult for students to accept, especially in cases with no obvious temperature increase. Finally, it may not be clear to students that some forms of energy, such as light, sound, and chemical energy, can be used to make things happen.

Some students of all ages have difficulty in identifying the sources of energy for plants and also for animals. Students tend to confuse energy and other concepts such as food, force, and temperature. As a result, students may not appreciate the uniqueness and importance of energy conversion processes like respiration and photosynthesis. Although specially designed instruction does help students correct their understanding about energy exchanges, some difficulties remain. [10] Careful coordination between The Physical Setting and The Living Environment benchmarks about conservation of matter and energy and the nature of energy may help alleviate these difficulties (NSDL, 2015).

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.

Life science

- Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
- Within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, to support growth, or to release energy.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

Connections to Other Courses

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.
- Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.

Life science

- The process of photosynthesis converts light energy to stored chemical energy by converting carbon dioxide plus water into sugars plus released oxygen.
- The sugar molecules thus formed contain carbon, hydrogen, and oxygen: Their hydrocarbon backbones are used to make amino acids and other carbon-based molecules that can be assembled into larger molecules (such as proteins or DNA), used for example to form new cells.
- As matter and energy flow through different organizational levels of living systems, chemical elements are recombined in different ways to form different products.
- As a result of these chemical reactions, energy is transferred from one system of interacting molecules to another. Cellular respiration is a chemical process in which the bonds of food molecules and oxygen molecules are broken and new compounds are formed that can transport energy to muscles. Cellular respiration also releases the energy needed to maintain body temperature despite ongoing energy transfer to the surrounding environment.
- Photosynthesis and cellular respiration (including anaerobic processes) provide most of the energy for life processes.
- Plants or algae form the lowest level of the food web. At each link upward in a food web, only a small fraction of the matter consumed at the lower level is transferred upward, to produce growth and release energy in cellular respiration at the higher level. Given this inefficiency, there are generally fewer organisms at higher levels of a food web. Some matter reacts to release energy for life functions, some matter is stored in newly made structures, and much is discarded. The chemical elements that make up the molecules of organisms pass through food webs and into and out of the atmosphere and soil, and they are combined and recombined in different ways. At each link in an ecosystem, matter and energy are conserved.
- Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.

Connections to NJSLS MATH & ELA

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-*

	PS3-3),(HS-PS3-4),*(HS-PS3-5)*
WHST.11-12.8	Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5)
WHST.9-12.9	Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS3-4),(HS-PS3-5)*
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-PS3-2),(HS-PS3-5)*
Mathematics -	
MP.2	Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)
MP.4	Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),*(HS-PS3-4)*,(HS-PS3-5)
HSN.Q.A.1	Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS3-1),(HS-PS3-3)
HSN.Q.A.2	Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3)
HSN.Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)