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This full-year Physical Science course focuses on traditional concepts in chemistry and physics and encourages exploration of new discoveries in this field of science. The course includes an overview of scientific principles and procedures and leads students toward a clearer understanding of matter, energy, and the physical universe. Concepts discussed include elements and the periodic table, properties of matter, chemical bonding and reactions, motion and forces, work and energy, thermal energy and heat, light and sound waves, and electricity and magnetism. Students conduct a variety of laboratory activities that develop skills in observation, use of scientific tools and techniques, data collection and analysis, and mathematical applications. As students refine and expand their understanding of physical science, they apply their knowledge in experiments that require them to ask questions and create hypotheses. Throughout the course, students solve problems, reason abstractly, and learn to think critically.

The course includes the following:

- Developing mindful, scientific habits, including the value of research and exploration of phenomena through inquiry and communication
- Independent reading of complex scientific texts
- Following procedures and practicing inquisitiveness and ethical choices in laboratory investigations
- Learning and applying content-related vocabulary in context
- Applying concepts to real-world situations
- Writing accurate, well-developed lab reports

The course is aligned to the Physical Science course requirements and includes the following features:

- To promote inquiry and a focus on big ideas, every lesson includes a guiding lesson question. Each lesson begins with a thought-provoking warm-up activity to engage students and activate or build on prior knowledge.
- The course incudes an abundance of rich graphics, charts, diagrams, animations, and interactives, which help students relate to and visualize the content.
- To help students apply concepts, the course contains nine labs with student guides, teacher guides, and guidance for completing a written laboratory report and/or reflection activity. Lab reports are intended to be teacher-scored.
- Students build their questioning skills by planning their own investigation.
- Multiple investigative projects embedded throughout the course provide students with opportunities to apply scientific and engineering practices. Projects require students to create devices for use in real-world applications, such as cooking with solar power, or apply conceptual knowledge to gain a greater understanding of scientific phenomena that occur throughout the natural world. All projects are intended to be teacher-scored.
• Reading assignments expose students to models for scientific and technical writing.
• Reading assignments utilize the CloseReader™ tool, which enables students to interact with the text by highlighting targeted words and phrases and adding purposeful sticky notes. Students also probe vocabulary words, investigate elements and features of the text with care, and benefit from auditory assistance.
• An interactive periodic table equips students to solve chemistry problems and understand, visualize, and describe matter.
• A variety of graphic organizers help students understand relationships between and among concepts.
• An emphasis on interpreting figures and data displays helps students read and understand information the way scientists present it.
• Real-world connections help students connect physical science to their everyday lives.
• Multiple writing items relate to real-world application of science and engineering practices.

Throughout the course, students meet the following goals:

• Examine the periodic table and determine the properties of an element.
• Investigate the structures, types, and properties of matter.
• Learn about chemical bonds and chemical reactions.
• Understand solutions and acid-base reactions.
• Explain the relationship between motion and forces.
• Recognize the interdependence of work and energy.
• Relate heat and temperature change on the macroscopic level to particle motion on the microscopic level.
• Demonstrate an understanding of waves, including sound and light.
• Analyze the connection between electricity and magnetism.
UNIT OVERVIEWS

UNIT 1: ATOMS AND THE PERIODIC TABLE

Estimated Unit Time: 20 Class Periods (970 Minutes)

In this unit, students examine the structure of the atom and the relationship between atoms and elements. Students investigate the historical development of atomic theory and how the current scientific model of the atom was developed. Students then identify the parts of the atom and apply that knowledge to describe elements and isotopes. Students further develop scientific literacy and research skills through the analysis of scientific articles about atoms and the development of atomic theory. Students investigate the periodic table and its trends. They explore the historical development of the periodic table and the properties of elements displayed within it. Students then analyze the groups of elements within the periodic table, including metals, nonmetals, and metalloids, and describe their properties and reactivity. Students also complete a multimedia presentation on a specific element to further develop scientific research and literacy skills.

For example, in the lesson Atomic Theory, students examine the historical development of atomic theory, including identifying how scientists such as Democritus, Dalton, Thomson, Rutherford, and Bohr conducted various experiments that led to an increased understanding of atomic structure over time. Students examine graphic models of the atom to analyze how changes in atomic theory affected the model of the atom. Near the end of the lesson, students read a scientific article discussing changes in atomic theory and the atomic model that have occurred over time and then utilize evidence from the article to describe how the model of the atom has evolved into its current state.

In the lesson Periodic Table, students examine the structure of the periodic table, including how its arrangement has changed over time based on investigations by scientists such as Lavoisier, Newlands, Mendeleev, and Moseley. Students identify trends in the organization of the periodic table and differentiate between the periods and groups of the periodic table. In addition, students evaluate the information used to identify individual elements in the periodic table. Upon completion of the lesson, students conduct research on specific elements utilizing appropriate reference sources and then create a multimedia presentation discussing various characteristics of their chosen element, including its properties and uses.
**Unit 1 Focus Standards**

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

<table>
<thead>
<tr>
<th>Standard Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>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 and the composition of the nucleus of atoms.</td>
<td>HS-PS1-1.</td>
</tr>
<tr>
<td>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.</td>
<td>HS-PS1-2.</td>
</tr>
<tr>
<td>Analyze the structure of the relationships among concepts in a text, including relationships among key terms (e.g., force, friction, reaction force, energy).</td>
<td>CCSS.ELA-Literacy.RST.9-10.5</td>
</tr>
<tr>
<td>Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2</td>
</tr>
<tr>
<td>Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2b</td>
</tr>
<tr>
<td>Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2d</td>
</tr>
<tr>
<td>Model with mathematics.</td>
<td>MP.4</td>
</tr>
<tr>
<td>Define appropriate quantities for the purpose of descriptive modeling.</td>
<td>HSN-Q.A.2</td>
</tr>
</tbody>
</table>
Unit 1 Common Misconceptions

- Atoms are made of the same substance as the macroscopic substance they compose (i.e., gold atoms are made of gold, iron atoms are made of iron, etc.).
  - Atoms are not made of the same substance as the macroscopic substance they compose. The properties of the substance are a result of the interactions that occur between the particles within the substance. For example, the substances graphite and diamond are both made of only carbon atoms. However, because of how the carbon atoms interact in these substances, they have very different properties.

- Atoms and ions that have the same number of protons will be the same size.
  - Negative ions are normally larger in size than the atoms of the element from which they form. The attraction of the nucleus of the negative ion to the electrons it contains is not as strong as that of the nucleus for the electrons in the original atom, so the ion is larger. Positive ions are normally smaller in size than the atoms of the element from which they form, as the nucleus of the positive ion has a greater attraction for the electrons it contains.

- Atoms, ions, and molecules are the same.
  - Atoms are the smallest building blocks of matter, and are composed of neutrons, protons, and electrons. Ions are atoms or molecules that are positively or negatively charged, due to the presence or absence of electrons (the number of electrons it contains does not equal the number of protons). Molecules are groups of two or more atoms that are bonded together chemically. They may consist of one or more types of elements, but an individual molecule will retain all of the properties of the substance it composes.

- The periodic table is arranged in order of increasing atomic mass.
  - Elements in the periodic table are arranged in order of atomic number.

- The mass number of an element is the same as the number of neutrons the element contains.
  - The mass number of an element is calculated by adding the number of protons and number of neutrons that an atom of the element contains. The number of neutrons in an atom of a specific element can differ. Atoms of an element that have the same number of protons but different numbers of neutrons are called isotopes.

- The isotopes and ions of an element are the same.
  - Isotopes are atoms of an element that have the same number of protons but different numbers of neutrons. Ions are atoms or molecules that are positively or negatively charged, due to the presence or absence of electrons (the number of electrons it contains does not equal the number of protons).
UNIT 2: STATES AND PROPERTIES OF MATTER

Estimated Unit Time: 18 Class Periods (855 Minutes)

In this unit, students investigate physical properties of matter, including the concepts of mass, weight, volume, and density. Students describe physical changes and apply the law of conservation of mass to examples of physical change. Students apply mathematical concepts to calculate the density of objects in a variety of real-world applications. Students complete a laboratory activity to garner a comprehensive understanding of the relationships among the mass, volume, and density of an object and further develop their scientific literacy skills through the completion of a scientific lab report for the activity. Next, students investigate aspects and properties of matter, including the characteristics and motion of atoms in different states of matter. In addition, students examine various state changes and the relationship between state changes and energy. Finally, students differentiate between both physical and chemical changes of matter and identify chemical properties of matter in real-world scenarios.

For example, in the lesson States of Matter, students compare multiple characteristics between major states of matter, including the ability to differentiate between the location and movement of atoms in solid, liquid, and gaseous states. In addition, students differentiate between the structures of crystalline and non-crystalline solids and investigate the properties of viscosity and surface tension, which are seen in liquids.

In the lesson Lab: Density of Solids, students conduct mathematical analyses to determine the density of various objects by measuring mass and volume and identify an unknown substance from just its density. To complete this assignment, students apply their knowledge of significant figures when calculating values.
### Unit 2 Focus Standards

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

<table>
<thead>
<tr>
<th>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 and the composition of the nucleus of atoms.</th>
<th>HS-PS1-1.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects.</td>
<td>HS-PS3-2.</td>
</tr>
<tr>
<td>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.</td>
<td>HSN-Q.A.1</td>
</tr>
<tr>
<td>Model with mathematics.</td>
<td>MP.4</td>
</tr>
<tr>
<td>Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.</td>
<td>HSA-CED.A.2</td>
</tr>
<tr>
<td>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.</td>
<td>HSA-CED.A.4</td>
</tr>
<tr>
<td>Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text.</td>
<td>CCSS.ELA-Literacy.RST.9-10.3</td>
</tr>
<tr>
<td>Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.1b</td>
</tr>
<tr>
<td>Use words, phrases, and clauses to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.1c</td>
</tr>
<tr>
<td>Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.4</td>
</tr>
<tr>
<td>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.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.5</td>
</tr>
</tbody>
</table>
Unit 2 Common Misconceptions

- The particles within a solid cannot move.
  - Particles within a solid can have small individual movements (vibrations), but they are unable to change position relative to the other particles in the solid.

- Gases do not have mass, so they cannot be matter.
  - Even though gases are invisible, they do still have mass and weight. One way that this can be demonstrated is by filling a balloon with air and hanging it on a balance stick. The stick will tip to the side containing the balloon and show that the air inside does have mass and weight.

- When a substance melts, it is because the individual atoms in the substance are melting.
  - Melting occurs when heat is added to a solid, changing its state to that of a liquid. When this change occurs, it is not because the individual atoms in the substance are melting, but rather because the heat changes the ability of the particles in the solid to move in relation to each other.

- When a substance changes state, it is because the atoms in the substance are changing state (i.e., atoms in a solid are solid and atoms in a liquid are liquid).
  - When a substance changes state, the amount of energy contained in the individual particles in the substance is changing. As energy in the individual particles increases, particles are able to move more easily in relation to each other. This phenomena is what creates changes of state from solid to liquid to gas. When the individual particles in a substance lose energy, particles are not able to move as easily in relation to each other. This phenomena is what creates changes of state from gas to liquid to solid.

- The bonds that make up a compound will always break when the substance melts or boils.
  - When a substance melts or boils, the amount of energy contained in the individual particles in the substance is changing. As energy in the individual particles increases, particles are able to move more easily in relation to each other. We observe melting or boiling because the bonds between the particles in the substance are broken, allowing individual particles to move. However, bonds within the particles themselves do not break.

- Ionic compounds can always conduct electricity.
  - Ionic compounds that are in a solid state will not conduct electricity. Ionic compounds that are dissolved in water or in a liquid form will conduct electricity.

- When a substance is boiling, it has reached its maximum temperature.
  - A substance that is boiling has reached the boiling point temperature, which is the temperature at which the liquid form of the substance can change into the gaseous form. Substances are able to continue to increase in temperature after they change into gases, so the boiling point is not the maximum temperature for many substances.
Substances increase in size because the particles that compose them are increasing in size.

- Substances increase in size due to the change in distance between the particles that compose the substance. When a substance expands, the particles that compose the substance move farther apart. When a substance contracts or shrinks, the particles that compose the substance move closer together.

The mass of an object is the same as its weight.

- The mass of an object measures how much matter is contained within it.
- Weight measures how much the force of gravity pulls on an object.

Substances that have the same volume must have the same density.

- Substances may have different densities and have the same volume. Density is dependent on both the mass and volume of an object. If an object has a very light mass, but the same volume as an object that has a greater mass, those objects will have different densities.
UNIT 3: CHEMICAL BONDING AND COMPOUNDS

Estimated Unit Time: 21 Class Periods (1050 Minutes)

In this unit, students investigate chemical bonding and its role in creating substances such as compounds and polymers. Students create and utilize electron dot diagrams to examine the three types of chemical bonds and how they form. Students also describe the characteristics of each type of bond and the relationships between these characteristics and the properties of compounds. Students then examine the structure of polymers and their applications to real-world scenarios, including an analysis of scientific articles on the uses of polymers.

For example, in the lesson Ionic Bonds, students examine the formation of ionic bonds, including the types of atoms involved in ionic bonding and how electrons are transferred between atoms in ionic bonds. Students also identify polyatomic ions, as well as characteristic properties of ionic compounds. Finally, students examine how ionic compounds form crystal structures and identify some applications of ionic compounds in the real world.

In the lesson Polymers, students analyze polymers to determine the effects of subunits on overall polymer structure. Students also identify real-world examples of both natural and synthetic polymers and differentiate between the benefits and limitations of both types. Students then apply their scientific literacy skills in analyzing technical readings on the uses of plastics and create written responses regarding the impact of plastics on society.
### Unit 3 Focus Standards

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and, as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

| 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-PS1-2 |
| Define appropriate quantities for the purpose of descriptive modeling. | HSN-Q.A.2 |
| Reason abstractly and quantitatively. | MP.2 |
| Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text. | CCSS.ELA-Literacy.RST.9-10.3 |
| Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. | CCSS.ELA-Literacy.WHST.9-10.2a |
| Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic. | CCSS.ELA-Literacy.WHST.9-10.2b |
| Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers. | CCSS.ELA-Literacy.WHST.9-10.2d |
| Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing. | CCSS.ELA-Literacy.WHST.9-10.2e |
| Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. | CCSS.ELA-Literacy.WHST.9-10.4 |
Unit 3 Common Misconceptions

- Students may have difficulty differentiating between molecules and compounds and may view these terms as equivalent.
  - **Molecules** are groups of two or more atoms that are bonded together chemically. They may consist of one or more types of elements, but an individual molecule will retain all of the properties of the substance it composes. **Compounds** are pure substances that are composed of two or more different elements. Compounds are always molecules, but molecules are not always compounds.

- Chemical bonds are either purely ionic or purely covalent.
  - **Ionic bonding** occurs when valence electrons are transferred between two atoms (one atom transfers its valence electrons to the other). **Covalent bonding** occurs when valence electrons are shared between two atoms. Depending on the types of atoms contained in a covalent bond, the bonding electrons may be shared equally or unequally, creating a partial ionic or partial covalent bond. Covalent bonds may be either non-polar (bonding electrons are shared equally) or polar (bonding electrons are shared unequally).

- Solutions can be pure substances.
  - A pure substance is a substance that cannot be separated into its components. Examples of pure substances include elements and compounds. A mixture is a substance that can be separated into its components. A solution is an example of a mixture.
UNIT 4: CHEMICAL REACTIONS

Estimated Unit Time: 20 Class Periods (960 Minutes)

In this unit, students investigate various aspects of chemical reactions, describe indicators for chemical reactions, identify reaction types, discern changes in reaction rate, and apply the law of conservation of mass and mathematical concepts to analyze and balance chemical equations. Students develop technological design skills by constructing a device that can regulate the release of energy in a chemical reaction. Finally, students complete a laboratory activity to gain a comprehensive understanding of the impact temperature and surface area have on the rate of a chemical reaction, and further develop their scientific literacy skills through the completion of a scientific lab report for the activity.

For example, in the lesson Types of Chemical Reactions, students examine types of chemical reactions, including synthesis, oxidation, combustion, decomposition, and replacement reactions. Students also identify the applications of various reaction types in real-world scenarios. Upon completion of the lesson, students apply their knowledge to design and construct a device that uses chemical processes to release thermal energy. Students also examine chemical equations to determine the depicted reaction type, then support the claim using evidence from the lesson.

In the lesson Lab: Rate of Chemical Reactions, students investigate the impact of temperature and surface area on the rate at which an antacid dissolves in water, then apply their mathematical skills to analyze graphs and apply their knowledge to a different real-world scenario. Additionally, students examine selected elements and describe their predicted physical/chemical properties, predict the outcome of a chemical reaction between individual sets of selected elements, and explain changes in reactions to form products. This lab includes real-world reactions and applications, in which students analyze the relationships between elements, bonding, chemical reactions, and chemical equilibrium, and understand hierarchies in chemical reactions. Finally, students participate in a group discussion before submitting their work.
### Unit 4 Focus Standards

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and, as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

<table>
<thead>
<tr>
<th>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.</th>
<th>HS-PS1-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.</td>
<td>HS-PS1-7</td>
</tr>
<tr>
<td>Model with mathematics.</td>
<td>MP.4</td>
</tr>
<tr>
<td>Define appropriate quantities for the purpose of descriptive modeling.</td>
<td>HSN-Q.A.2</td>
</tr>
<tr>
<td>Reason abstractly and quantitatively.</td>
<td>MP.2</td>
</tr>
<tr>
<td>Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text.</td>
<td>CCSS.ELA-Literacy.RST.9-10.3</td>
</tr>
<tr>
<td>Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.1a</td>
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<tr>
<td>Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.1b</td>
</tr>
<tr>
<td>Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2d</td>
</tr>
<tr>
<td>Establish and maintain a formal style and objective tone while attending to the norms and conventions of the discipline in which they are writing.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2e</td>
</tr>
<tr>
<td>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.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.5</td>
</tr>
<tr>
<td>Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.4</td>
</tr>
</tbody>
</table>
Unit 4 Common Misconceptions

- Atoms are not conserved in chemical reactions.
  - New substances form during chemical reactions due to the rearrangement of the atoms and bonds contained within the reactants. For example, in the chemical reaction that occurs between HCl and NaOH, the new substances NaCl and H$_2$O are formed. None of the atoms of the individual reactants are lost during this reaction, but rather the substances break their original chemical bonds and form new chemical bonds to create new substances.

- The products formed in chemical reactions result from the creation of new matter.
  - New substances form during chemical reactions due to the rearrangement of the atoms and bonds contained within the reactants. For example, in the chemical reaction that occurs between HCl and NaOH, the new substances NaCl and H$_2$O are formed. New matter is not created during this reaction. Instead, the original substances break their chemical bonds and form new chemical bonds to create new substances.

- Chemical reactions always require heat to occur.
  - While there are many chemical reactions that require heat to occur, there are a variety of chemical reactions that produce heat as they occur. Exothermic reactions are heat-releasing, while endothermic reactions are heat-absorbing.

- Matter disappears in some chemical reactions.
  - New substances form during chemical reactions due to the rearrangement of the atoms and bonds contained within the reactants. For example, in the chemical reaction that occurs between HCl and NaOH, the new substances NaCl and H$_2$O are formed. None of the matter contained in the individual reactants is lost during this reaction, but rather the substances break their original chemical bonds and form new chemical bonds to create new substances.
UNIT 5: MIXTURES, SOLUTIONS, AND ACID-BASE REACTIONS

Estimated Unit Time: 12 Class Periods (555 Minutes)

In this unit, students investigate various aspects of mixtures and solutions, including identifying types of mixtures and their properties. Students then compare types of solutions and analyze the factors that affect them, such as those that impact the rate of dissolution and the solubility of a substance. Students then describe solubility and examine the solubility of different substances. Additionally, students investigate acids and bases, including the application of acids and bases in real-world scenarios. Students examine the properties and reactions of acids and bases, and describe how pH is used to identify them. Finally, students complete a laboratory activity to further their understanding of how the pH of acids and bases is determined using a multi-use indicator. Students then develop their scientific literacy skills through the completion of a scientific lab report for the activity.

For example, in the lesson Solubility, students investigate various factors that impact the solubility of a material, as well as differentiate between saturated and supersaturated solutions. In addition, students compare various solutions to determine which is the most soluble.

In the lesson Lab: Acids and Bases, students analyze various household materials in order to determine pH and classify each as an acid or base. Students also investigate the impact of diluting on the acidity and basicity of a solution. In completing this assignment, students apply their knowledge of significant figures when calculating pH and pOH values and communicate the results of the laboratory investigation in a written lab report.
## Unit 5 Focus Standards

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and, as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

<table>
<thead>
<tr>
<th>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.</th>
<th>HS-PS1-2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects.</td>
<td>HS-PS3-2.</td>
</tr>
<tr>
<td>Model with mathematics.</td>
<td>MP.4</td>
</tr>
<tr>
<td>Define appropriate quantities for the purpose of descriptive modeling.</td>
<td>HSN-Q.A.2</td>
</tr>
<tr>
<td>Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text.</td>
<td>CCSS.ELA-Literacy.RST.9-10.3</td>
</tr>
<tr>
<td>Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2a</td>
</tr>
<tr>
<td>Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2b</td>
</tr>
</tbody>
</table>
Unit 5 Common Misconceptions

- Solutes do not take up any space in a solution.
  - When a solution is formed, one substance (the solute) dissolves into a second substance (the solvent). When this occurs, the mass of the solute is conserved, and the overall mass of the solution will be equal to the mass of the solute and the mass of the solvent.

- When a solute dissolves, only its taste and/or color remains in the solution.
  - When a solution is formed, one substance (the solute) dissolves into a second substance (the solvent). When this occurs, the mass of the solute is conserved, and the overall mass of the solution will be equal to the mass of the solute and the mass of the solvent.

- When a solute dissolves, it becomes a new substance.
  - When a solute dissolves into a solvent, the solute itself does not change into a different substance. Instead, the solute separates into smaller particles and spreads throughout the solvent.

- If a substance contains H, it is an acid, and if it contains OH, it is a base.
  - There are many substances that contain H that are not acidic, and substances that contain OH that are not basic. For example, methane (CH₄) is a non-acidic substance, while alcohols contain OH and are able to act as either acids or bases.

- If a material burns you or eats away a material, it is an acid.
  - Substances that are corrosive will damage and/or destroy other substances they come in contact with. While there are many acids that are corrosive, there are many bases that are also corrosive in nature, such as ammonium hydroxide, potassium hydroxide, and sodium hydroxide.

- pH measures only the acidity of a solution.
  - pH is a measurement of the concentration of hydrogen ions present in a solution. The concentration of these ions determines the acidity or basicity of a solution.
UNIT 6: MOTION AND FORCES

Estimated Unit Time: 25 Class Periods (1250 Minutes)

In this unit, students investigate various aspects of one- and two-dimensional motion, including concepts of speed, velocity, acceleration, and Newton’s three Laws of Motion. Students apply mathematical concepts such as the solving of multiple mathematical equations, calculating slope, calculating an average, graph analysis, and an appropriate use of significant figures. Students differentiate between balanced and unbalanced forces and analyze their impacts on the motion of objects, as well as examine the impacts of frictional and gravitational forces on motion. They further analyze and apply Newton’s Laws of Motion to real-world situations involving one-dimensional motion and momentum. Students also complete two laboratory activities to gain a comprehensive understanding of the relationships between position, velocity, acceleration, and momentum of an object, and further develop their scientific literacy skills through the completion of scientific lab reports for the activities.

For example, in the lesson Momentum, students investigate various aspects of momentum, including performing momentum calculations, comparing the momentum of different objects, and applying the law of conservation of momentum to real-world scenarios. Students then apply their knowledge of momentum and its conservation, as well as their technological design knowledge, to create a device that will protect an egg from breaking when it is dropped from a designated height.

In the lesson Lab: Newton’s Laws of Motion, students plan and complete a laboratory experiment to investigate and verify Newton’s first and second laws of motion. In the investigations, students construct a racetrack and use a toy race car to examine the impact of inertia on the car as it hits an obstacle, as well as the impact of changing force on the car’s acceleration. Students discuss experimental procedures, possible results, collected data, and conclusions drawn to determine possible sources of error and additional relevant information for creating their lab reports.
### Unit 6 Focus Standards

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and, as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

| Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. | HS-PS2-1. |
| Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. | HS-PS2-2. |
| Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. | HS-PS3-3. |
| 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. | HSN-Q.A.1 |
| Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. | HSA-CED.A.2 |
| Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. | HSA-CED.A.4 |
| Define appropriate quantities for the purpose of descriptive modeling. | HSN-Q.A.2 |
| Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text. | CCSS.ELA-Literacy.RST.9-10.3 |
| Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension. | CCSS.ELA-Literacy.WHST.9-10.2a |
| Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic. | CCSS.ELA-Literacy.WHST.9-10.2b |
Unit 6 Common Misconceptions

- Distance is the same as displacement.
  - **Distance** is a measurement of how much ground an object has covered while it is moving. **Displacement** is a measurement of how much an object’s overall position has changed from its original location.

- Speed is the same as velocity.
  - **Speed** measures the rate at which an object is moving. **Velocity** measures both the rate at which an object is moving, as well as the direction in which it is moving.

- If an object is accelerating, it is always increasing in speed.
  - **Acceleration** measures the rate at which an object’s movement is changing. The movement of an object can change at a positive rate (increasing in velocity) or at a negative rate (decreasing in velocity). When an object is moving at a higher velocity, it has a positive acceleration. When it is moving at a lower velocity, it has a negative acceleration.

- The distance between two charged objects does not have an effect on the electrostatic force between them.
  - The distance between two charged objects does effect the force seen between them. When charged objects that are closer to each other, there is a greater amount of electrostatic force between them. When charged objects are farther apart, there is a smaller amount of electrostatic force between them.

- The force of gravity is stronger than the electrostatic force.
  - The strength of the gravitational force is dependent on the mass of an object and the distance it has from another object. Gravitational force is weak between atoms because the mass of an atom is extremely small. Gravitational force is stronger between planets because the mass of a planet is much larger.

- When an object is at rest, there are no forces acting on it.
  - When an object is at rest, all forces that are acting upon the object are balanced, so the object is in equilibrium. When an object is moving, the forces acting upon the object are unbalanced, thereby causing motion to occur.
UNIT 7: WORK, POWER, AND ENERGY

Estimated Unit Time: 23 Class Periods (1125 Minutes)

In this unit, students investigate work, power, technological design, energy, and energy transformations, and apply what they learn to real-world scenarios. Students examine the relationships between force, work, and power, and apply their mathematical skills to determine amounts of work, power, potential energy, and kinetic energy done in specific systems and situations. In addition, students analyze simple machines, calculating the mechanical advantage provided by each different type of machine, and assess the law of energy and how it applies to real-world energy transformations. Finally, students complete a laboratory activity in order to develop a comprehensive understanding on the relationships between the mass, speed, and kinetic energy of an object. Students then further develop their scientific literacy skills through the completion of a scientific lab report for the activity.

For example, in the lesson Lab: Kinetic Energy, students launch a beanbag into the air from a lever while utilizing a counterweight. Students adjust the amount of counterweight and the height from which the weight is dropped in order to investigate the effects of speed and mass on kinetic energy, as well as how kinetic energy affects the height reached by the beanbag. Students then apply their experimental knowledge to analyze kinetic energy graphs.

In the lesson Simple Machines, students compare and contrast the six types of simple machines and identify applications of these machines in real-world situations, such as in the human body and in common tools. Students then investigate and calculate the mechanical advantage provided by simple machines, and apply what they know of simple machines and mechanical advantage to create written responses on real-world applications of each.
### Unit 7 Focus Standards

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and, as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

| Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects. | HS-PS3-2. |
| Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. | HS-PS3-3. |
| 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. | HSN-Q.A.1 |
| Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. | HSA-CED.A.2 |
| Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. | HSA-CED.A.4 |
| Reason abstractly and quantitatively. | MP.2 |
| Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text. | CCSS.ELA-Literacy.RST.9-10.3 |
| Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence. | CCSS.ELA-Literacy.WHST.9-10.1a |
| Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns. | CCSS.ELA-Literacy.WHST.9-10.1b |
| Draw evidence from informational texts to support analysis, reflection, and research. | CCSS.ELA-Literacy.WHST.9-10.9 |
Unit 7 Common Misconceptions

- Work is performed when any force is applied over any distance.
  - Work is only done on an object when a force causes an object to move. If a force is placed on an object, but the object does not move, then work is not being done.

- When an object is resting, it does not have any energy.
  - Objects that are at rest contain potential energy. **Potential energy** is the energy that is stored within an object that can cause the object to move. It is also known as the energy of an object’s position.

- Kinetic energy will be doubled when the speed of a moving object is doubled.
  - There is a direct proportional relationship between kinetic energy and the square of the velocity of a moving object. When the velocity of an object is doubled, its kinetic energy will increase by a factor of four. If the velocity of an object was tripled, its kinetic energy would increase by a factor of nine, and so on.
UNIT 8: THERMAL ENERGY AND HEAT

Estimated Unit Time: 15 Class Periods (705 Minutes)

In this unit, students investigate thermal energy and heat, how temperature relates to kinetic energy, and the different methods of heat transfer. Students apply their mathematical skills to convert temperature readings between the temperature scales Celsius, Fahrenheit, and Kelvin, and differentiate between thermal energy and heat, analyzing various materials to predict the flow of thermal energy between objects. In addition, students examine conduction, convection, and radiation as methods of heat transfer and where they occur in real-world situations. Students develop their technological design skills through the development of a solar cooker and complete a laboratory activity to enhance their comprehensive understanding of the impact of mass and material type on thermal energy transfer. Finally, students further develop their scientific literacy skills through the completion of a scientific lab report for the laboratory activity.

For example, in the lesson Temperature and Thermal Energy, students investigate the relationships between kinetic energy, temperature, and the movement of particles in states of matter. Students also compare methods of measuring temperature and convert temperature readings between the various scales of measurement. In completing this assignment, students apply their knowledge of significant figures when calculating temperature values.

In the lesson Radiation, students investigate how electromagnetic waves transfer thermal energy via radiation, as well as factors that impact the absorption and reflection of radiated energy by objects. In addition, students analyze real-world scenarios to determine if heat transfer by radiation is occurring. Finally, students apply their knowledge of radiation and technological design to create a solar cooker.
### Unit 8 Focus Standards

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and, as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

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<thead>
<tr>
<th>Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects.</th>
<th>HS-PS3-2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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).</td>
<td>HS-PS3-4.</td>
</tr>
<tr>
<td>Define appropriate quantities for the purpose of descriptive modeling. Reason abstractly and quantitatively.</td>
<td>HSN-Q.A.2 MP.2</td>
</tr>
<tr>
<td>Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text.</td>
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<td>Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.</td>
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<td>Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2b</td>
</tr>
</tbody>
</table>
Unit 8 Common Misconceptions

- When energy is transformed, it is changed completely from one form into another, and no energy is lost.
  - While much of the energy will be changed to the new form when energy is transformed, some of the energy within the system will be converted into a less organized form of energy, such as heat. For example, when a flashlight is turned on, it will give off both light energy and heat energy, not just light energy.

- The size of an object will affect its temperature.
  - There are several factors that affect the change of temperature that will occur within an object when heat energy is transferred to it. These factors include mass of the object, composition of the object, and how much heat energy is transferred to the object. Size does not have an impact on how an object changes temperature.
UNIT 9: WAVES, SOUND, AND LIGHT

Estimated Unit Time: 23 Class Periods (1150 Minutes)

In this unit, students investigate properties and interactions of mechanical and electromagnetic waves. Students compare and contrast transverse and longitudinal waves, investigate how waves carry energy, and apply their mathematical skills to calculate amplitude, wavelength, frequency, and wave speed. In addition, students investigate the impact of various wave interactions on wave direction, such as reflection, refraction, and diffraction. They identify how wave propagation through different media affects wave speed. Students also investigate the electromagnetic spectrum and the properties of light, as well as examine the law of reflection and determine how it impacts the formation of images by different types of mirrors, such as plane mirrors. Students then examine refraction and analyze ray diagrams to describe the types of images formed by concave and convex lenses. Finally, students analyze the application of both sound waves and light waves in various real-world situations, and then further develop their scientific literacy and research skills through the analysis of a scientific article regarding the real-world applications of lenses in tools such as cameras and telescopes.

For example, in the lesson Using Sound, students investigate various ways in which sound is used in the real world, such as its applications in echolocation, ultrasound, and radio, and how wave properties affect these applications. Students then apply their scientific literacy skills to analyze a technical reading on analog and digital signals and create a written response regarding the advantages and disadvantages of both signals in various applications.

In the lesson The Electromagnetic Spectrum, students identify different electromagnetic waves, such as radio waves, infrared, and X-rays, and investigate differences in wavelength. Students then explore the application of real-world uses for electromagnetic waves including thermal imaging, X-rays, and the use of ultraviolet light in the field of forensics. Finally, students examine multiple claims regarding the effects of electromagnetic radiation on the human body, as well as recommendations for addressing some of the present issues, to develop an opinion/scientific claim paper regarding the benefits and disadvantages of using electromagnetic radiation in medical applications as well as propose their own solution to one of the present issues.
**Unit 9 Focus Standards**

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and, as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

| Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. | HS-PS4-1 |
| Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text. | CCSS.ELA-Literacy.RST.9-10.3 |
| 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. | HSN-Q.A.1 |
| Define appropriate quantities for the purpose of descriptive modeling. | HSN-Q.A.2 |
| Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence. | CCSS.ELA-Literacy.WHST.9-10.1a |
| Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience’s knowledge level and concerns. | CCSS.ELA-Literacy.WHST.9-10.1b |
Unit 9 Common Misconceptions

- Waves that travel in opposite directions along a spring or rope will bounce off of each other when they meet.
  - Waves that travel in opposite directions will meet within a medium and experience either constructive or destructive wave interference. **Constructive interference** occurs when two waves have a displacement in the same direction. **Destructive interference** occurs when two waves have a displacement in opposite directions.
- The particles of a medium will move with a wave that travels through it.
  - Particles of a medium will change their movement depending on the type of wave that is travelling through the medium. Particles that encounter **transverse waves** will move perpendicular to the wave motion. Particles that encounter **longitudinal waves** will move parallel to the wave motion.
- Sound will move more slowly through solids than through air.
  - Sound moves more quickly through solids due to the smaller distance between the particles contained in the solid.
- The pitch of an object can change if you hit the object harder.
  - The loudness of an object will change if you hit the object harder, due to the increase in the initial vibration.
- The pitch of a sound is the same as its loudness.
  - **Pitch** is a measurement of how high or low a sound is. **Loudness** is a measurement of the amplitude of a sound.
- White light is only made of one color.
  - Each wavelength of light is a particular color (red, blue, purple, etc.) White light is composed of all wavelengths of light, so it contains all colors of light.
- Light will only be reflected from a shiny surface, such as a mirror.
  - Reflection occurs when light bounces off an object. When light bounces off of a rough object, rather than a shiny or smooth object, it undergoes diffuse reflection because the light is reflected in multiple directions, rather than in just one direction.
- Light does not change direction when it passes through a transparent material.
  - Refraction occurs when light waves bend as they pass from one transparent material to another. Light waves refract due to a change in speed as the wave moves from one medium to another.
UNIT 10: ELECTRICITY AND MAGNETISM

Estimated Unit Time: 20 Class Periods (995 Minutes)

In this unit, students investigate various aspects of electricity, including electrical currents and circuits, and electricity’s relationship to magnetism. Students examine how objects become electrically charged and compare factors that impact electric force and electric fields. Students then investigate the relationship between electric currents, voltage, and resistance, and develop their mathematical skills by performing calculations using Ohm’s law. Students also investigate the difference between open and closed series and parallel circuits using diagrammatic models. Finally, students describe properties of magnets and magnetic fields, and then investigate how electric currents and magnetism can create each other. To further their understanding, students examine some applications of electromagnetism in real-world scenarios, such as in generators and motors, and develop their scientific literacy and research skills through the analysis of a scientific article regarding additional applications of electromagnetism. Students also complete a laboratory activity to further their understanding of the relationships between electric and magnetic fields by examining how two or more objects interact within these fields. Students develop magnetic/electric field diagrams and identify the directions of forces exerted on objects within the fields, then use the diagrams and their observations to analyze the objects’ interactions and interpret energy changes in the systems.

For example, in the lesson Electric Circuits, students differentiate between the parts of an electric circuit, as well as compare and contrast series and parallel circuits. Students then apply their knowledge to written predictions regarding circuits in real-world situations.

In the lesson Lab: Magnetic and Electric Fields, students plan an investigation to explore interactions between an electric current and a magnetic field. They use bar magnets, magnetic filings, and a compass to map a magnetic field. They then investigate how charged materials can create an observable electric field. Finally, they create simple electromagnets to investigate the relationship between a magnetic field and an electric current.
## Unit 10 Focus Standards

The following focus standards are intended to guide teachers to be purposeful and strategic in both what to include and what to exclude when teaching this unit. Although each unit emphasizes certain standards, students are exposed to a number of key ideas in each unit, and, as with every rich classroom learning experience, these standards are revisited throughout the course to ensure that students master the concepts with an ever-increasing level of rigor.

<table>
<thead>
<tr>
<th>Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.</th>
<th>HS-PS2-5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects.</td>
<td>HS-PS3-2.</td>
</tr>
<tr>
<td>Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.</td>
<td>HS-PS3-3.</td>
</tr>
<tr>
<td>Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.</td>
<td>HS-PS3-5.</td>
</tr>
<tr>
<td>Define appropriate quantities for the purpose of descriptive modeling.</td>
<td>HSN-Q.A.2</td>
</tr>
<tr>
<td>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.</td>
<td>HSN-Q.A.1</td>
</tr>
<tr>
<td>Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.</td>
<td>HSA-CED.A.4</td>
</tr>
<tr>
<td>Reason abstractly and quantitatively.</td>
<td>MP.2</td>
</tr>
<tr>
<td>Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks attending to special cases or exceptions defined in the text.</td>
<td>CCSS.ELA-Literacy.RST.9-10.3</td>
</tr>
<tr>
<td>Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2a</td>
</tr>
<tr>
<td>Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience’s knowledge of the topic.</td>
<td>CCSS.ELA-Literacy.WHST.9-10.2b</td>
</tr>
</tbody>
</table>
Unit 10 Common Misconceptions

- Objects become positively charged by gaining protons.
  - Objects become positively charged when they lose electrons.
- Electricity flows like liquids do.
  - Electricity is caused by the flow of charged particles from one place to another. This differs from the flow of liquids, which is the movement of the particles of the liquid in relation to each other.
- The size of a magnet will affect its strength (i.e., the larger a magnet is, the stronger it is).
  - The strength of a magnet is affected by the type of material it is composed of. Super magnets have the strongest pull, while common magnets have a lesser magnetic pull. A small super magnet would have a higher strength than a larger common magnet.
- Metal objects will always be attracted to magnets.
  - Not all metal objects are attracted to magnets. Magnets are attracted to metals with magnetic properties, such as iron, nickel, and cobalt. Other metals, such as copper and aluminum, do not have magnetic properties and are not attracted to magnets.
INTRODUCTION

Listening comprehension and speaking skills used in classroom discussions are crucial to learning and the development of literacy (Horowitz, 2015 citing Biber, 2006; Conley 2013; Hillocks, 2011; and Kellaghn, 2001). Classroom discussions help students become personally involved in their education by helping both teachers and students achieve a variety of important goals. Effective classroom discussions enhance student understanding by broadening student perspectives, adding needed context to academic content, highlighting opposing viewpoints offered by other participants, reinforcing knowledge, and helping establish a supportive learning community.

PROMOTING EFFECTIVE DISCUSSIONS

Edgenuity lessons set the foundation for rich, in-depth student discussions that can be facilitated by a classroom instructor and directed using the guidelines that follow. Excellent discussions often begin with well-planned questions with which students can connect, or that engage or capture students’ imaginations.

1. As the class begins, use material that is familiar or comfortable for students personally, and then progress toward ideas central to course content.

2. If a question fails to garner a response or doesn’t seem to gain the interest of your students, try rephrasing or provide an example. Even the best instructors ask questions that go nowhere; the trick is to keep trying.

3. Encourage students to create and ask their own discussion questions, gradually shifting the responsibility for moving discussions forward from the instructor to the students as students demonstrate readiness.

4. Support students who struggle with articulating and supporting their views by providing some of the discussion questions to them beforehand. The opportunity to process the question and make notes can help reticent students participate more readily.

5. Use questions that draw upon knowledge (Remembering).
   - Use Blooms verbs to develop questions that allow students to demonstrate understanding at multiple levels. For example:
     - Questions that ask students to demonstrate comprehension:
       - What is meant when the author writes...?
       - Will you state or interpret in your own words...?
     - Questions that encourage reasoning or analysis of an idea or text:
       - I wonder why...?
       - What would happen if...?
       - What could have been the reason...?
• What conclusions can you draw...?
• Questions that promote evaluation of a process or idea:
  o What might be better...?
  o Would you agree that...?
• Questions that promote synthesis of a concept:
  o Can you propose an alternative...?
  o How could you change (modify) the process (plan)?
  o What can you infer from...?
  o Can you make the distinction between...?
• Questions that promote application of a concept:
  o How could this idea be applied to...?
  o How could you use this information to...?

Effective discussions usually begin with clear ground rules. Make sure students understand your discussion guidelines. For example:

• Allow students to challenge one another, but do so respectfully. Participants may comment on the ideas of others, but must refrain from criticizing individuals.
• Encourage students who are offended by anything said during discussion to acknowledge it immediately.
• Encourage students to listen actively and attentively.
• Do not allow students to interrupt one another.
• Do not allow students to offer opinions without supporting evidence.
• Make sure students avoid put-downs (even humorous ones).
• Encourage students to build on one another’s comments; work toward shared understanding.
• Do not allow one student or a small number of students to monopolize discussions.
• Some instructors ask each class to develop its own rules for discussions. The instructor must then take care to honor those rules and to make sure students honor them as well.
SUGGESTED DISCUSSION QUESTIONS FOR PHYSICAL SCIENCE

Research supports building in time for students to talk about texts after they read them. This time should enable readers to recompose, self-reflect, analyze, and evaluate the meaning of the text (Cosent Lent & Gilmore, 2013; Horowitz, 2015). Please use the questions located below to guide your physical science in-class discussions.

Unit 1: Atoms and the Periodic Table

1. From the reading, “Will the Real Atomic Model Please Stand Up,” Democritus proposed that atoms were the smallest unit of matter. We now know about protons, neutrons, and electrons, but these are composed of even smaller particles, called “quarks.” Do you think there is a smallest, indivisible unit of matter? Why or why not?
2. The reading “To Study or Not to Study Atoms” discusses applications of the study of atoms to real-world situations. Besides electrical devices and medicine, what other forms of technology have advanced from studying atoms?
3. Why are the valence shells that are farther away from the nucleus less reactive than the ones that are closer?
4. Think about how the periodic table is organized. Why is it useful to organize it this way? What evidence supports your answer?
5. Why is living matter, such as trees, insects, and humans, primarily made of nonmetallic elements? Can living matter ever primarily be composed of metals?
6. Why would knowing the different properties of metals, nonmetals, and metalloids be useful for a mining operation? Provide some examples of properties that would be useful for a copper miner to know.
7. In “Madame Curie’s Passion,” what were some of the most important contributions Marie Curie made to chemistry? How did she physically suffer as a result?
8. From the readings, “4 New Elements Are Added to the Periodic Table,” “Four New Names Officially Added to the Periodic Table of Elements,” and “Here is a Photo of a Single Atom,” what atomic breakthroughs have been made in the last decade? What breakthroughs are you interested in seeing in the next decade?
9. In “Madame Curie’s Passion,” what were some ways that Marie was treated differently than Pierre by the scientific community? Why do you think this was, and are women scientists treated differently in modern times?

Unit 2: States and Properties of Matter

1. Give examples of some situations in which you would want to know the density of objects you use.
2. Why is it easier for states to change at high altitude, like on Mt. Everest?
3. In a system, if you increase the potential energy, why does kinetic energy decrease? How does this relate to the Law of Conservation of Energy?
4. What are some examples of state changes you have seen, and consistent patterns they have exhibited? For example, how often do the state changes occur, and in what conditions? What are some consistent physical properties you have observed?

5. The deeper in the ocean you go, the colder the water is. Why aren’t the deepest parts of the ocean made of ice?

6. Have you seen sublimation occurring? Where would this normally occur? What is an example of sublimation?

7. Why are melting, freezing, and vaporization the most common state changes?

8. How would you calculate the volume of a soccer ball? A soccer ball and a bowling ball are about the same volume, so would you expect their densities to be similar? Why?

9. Do you think there can be other states of matter besides solids, liquids, and gases? Why or why not?

10. Do you think there can be states of matter that have properties of both a solid and a liquid? Why or why not?

11. From the reading, “New Form of Water, Both Liquid and Solid, Is ‘Really Strange,’” what is superionic water? What are some ways that superionic water is different from normal water?

Unit 3: Chemical Bonding and Compounds

1. What are some benefits to a systematic approach to chemical names?

2. Do you think that systematic chemical names or chemical formula are easier to read? Why?

3. From the reading, “Chemists Find a New Chemical Bond” by Popular Science, a new bond type was discovered in 2014. Why do you think we did not know about this type of bond before?

4. Chemical names can sometimes sound intimidating. From the reading “DIHYDROGEN MONOXIDE: UNRECOGNIZED KILLER,” what does the name for water (“dihydrogen monoxide”) sound like? Why do you think so many people were willing to ban this “chemical” after hearing about it?

5. Why are covalent bonds only between nonmetals?

6. Why are ionic bonds only between metal and nonmetal combinations?

7. Why are metallic bonds only between metals?

8. Salt and sugar look identical. Why do they behave differently when stirred into water? How does salt react to water that is different from sugar?

9. What environmental impact do you think there is in throwing out synthetic polymers, like plastic?

Unit 4: Chemical Reactions

1. Based on the reading “When the Water Turned Brown,” by the New York Times, how was lead introduced into the city’s water supply? How was the crisis handled by the city, and what could they have done to prevent it?

2. Glaciers, a solid, float on water, a liquid. How can water be in two different states in the same conditions? Think about this in regards to activation energy.
3. Describe some chemical reactions you have seen in real life. What did the reactions look like? What caused them to happen?
4. Why is the Law of Conservation of Mass so important when understanding chemical reactions?
5. How does bleach remove stains? Is this a chemical reaction?
6. What are some chemical reactions you are already familiar with in your life?
7. Why must mass always be conserved in a chemical reaction? What would happen if it weren’t?

Unit 5: Mixtures, Solutions, and Acid-Base Reactions
1. Is a soda a homogeneous mixture or a heterogeneous mixture? Why? Is there a difference if a soda can is opened or closed?
2. Water is purified artificially by going through a water treatment plant, which filters out the impurities. In nature, what are some ways that impurities are removed from water?
3. What are some of the pros and cons of using a screen versus using a filter to remove impurities from water?
4. Blood looks homogenous, so why does it not evaporate? Which separation technique would you use to separate out the solutes and the solvent in blood?
5. You are at the grocery store and pick up a can of soup that says, “Made from concentrate.” What does this mean? How would you prepare this soup to eat it?
6. Calcite is a mineral composed of calcium carbonate. What method from the unit could be used to detect if a particular mineral is calcite or not? Why?
7. Pure water has a pH of 7, but impurities in water can increase or decrease the pH. For instance, rainwater with a pH of less than 7 is called acid rain. How do you think acid rain would affect farm crops and limestone?
8. From the reading, “What is Acid Rain” by National Geographic, how is acid rain produced? What are some of the effects acid rain has on ecosystems? What can people do to prevent it?
9. From the readings “An Ingenious 20-Cent Paper Centrifuge Could Save Lives from Malaria” and “Sunlight-Powered Purifier Could Clean Water for the Impoverished,” what are ways that technology has found inexpensive solutions for impoverished areas? What are some other ways that you can think of?
10. From the reading, “What is Ocean Acidification?” by NOAA, what is making oceans more acidic? What effect does this have on ocean biology?

Unit 6: Motion and Forces
1. What are some situations in which a person could have a positive direction but zero displacement? Can you think of any examples in which a person could have positive displacement and zero distance?
2. Distance and displacement use the same unit of measurement. Why are they not the same thing? What are some examples in which distance and displacement are equal? What are some examples in which they are not equal?
3. Speed and velocity use the same unit of measurement. Why are they not the same thing? What are some examples in which speed and velocity are equal? What are some examples in which they are not equal?

4. When making a calculation with numbers that have different units of measurement, such as using distance and time to find speed, why is it important to write down the units of measurement in the equation?

5. In a position-versus-time graph, time is always on the x-axis. Why do you think this is? What could happen to a graph on which position was on the x-axis and time was on the y-axis?

6. How does velocity relate to acceleration?

7. In your motion lab, you changed the racetrack to change the velocity and acceleration of a car. In real life, racers must design their cars to take advantage of velocity and acceleration. What are some ways that a car can be designed in order to make it more competitive on the racetrack?

8. Think about a massive tug-of-war, in which two groups of people each pull on the ends of a rope, as a force diagram. What are the forces at play here? How do teamwork and counteracting forces influence the outcome of the tug-of-war? Why do the forces need to be unbalanced in order to one team to win?

9. A shooting star is actually a piece of rock entering Earth’s atmosphere from space. Why do you see a shooting star as a brief glow in the sky?

10. If you drop a hammer and a feather, which hits the ground first and why? In 1971, astronaut David Scott dropped a hammer and a feather at the same time on the moon. What do you think happened, and why?

11. From the reading, “The Strange, Deadly Effects Mars Would Have on Your Body,” what are some of the ways our bodies have adapted to Earth’s gravity? What difficulties could humans face living for extended periods of time in a different gravity, such as a colony on Mars?

12. From the reading, “Physics and the Automotive Industry,” how do car manufacturers use physics to design the best-performing vehicles?

Unit 7: Work, Power, and Energy

1. Think about a horse race. What is the difference between power and work as they relate to the horses? Which is more important to winning? Why?

2. Remember the physical property of thermal conductivity from Unit 1. How does thermal conductivity relate to thermal energy? What materials would you expect to have high thermal energy?

3. Remember the physical property of electrical conductivity from Unit 1. How does electrical conductivity relate to electrical energy? Name some materials you would expect to have high electrical energy.

4. How are chemical and nuclear energy related to the structure of atoms, molecules, and compounds?

5. Name examples of fossil fuels. What kind of energy do fossil fuels have? What are some ways we use them?
6. Think about the ways we generate energy, such as using nuclear power plants and burning fossil fuels. What items in your home use electricity, and are therefore powered by one or more of these methods?
7. Think about the definition of a machine. Is a car a machine? Is a bike? How about a screwdriver? Describe some machines you have seen around your school and discuss how they make work easier.
8. From the reading “World of Change: Global Temperatures” by NASA, how has temperature changed since 1890? Is this something to be concerned about? Why?
9. Coal, petroleum, and natural gas can only be made in an oxygen-free environment. Why is that? What happens to plant and animal remains in an oxygenated environment?
10. What are the benefits of conservation? In what ways do you reduce, reuse, or recycle?
11. Think about renewable and nonrenewable resources. What are some examples of each? What are the benefits and the disadvantages of each?

Unit 8: Thermal Energy and Heat
1. Which temperature scale do you think is the most useful? Think about the scale as used in your everyday life as well as in science. Why do you think we have three different scales for temperature?
2. If you touch something metallic, it often feels cold. Does the cold transfer into your hand? What is happening when something that feels cold touches you?
3. If you need to clean a stain, is it better to use hot or cold water? Why?
4. What are some examples of conducting and insulating objects in your home? What are their uses? Based on their uses, why are each of these objects made out of conducting or insulating materials?
5. When you boil water on the stove, what happens to the movement of the water molecules? Why?
6. Think about being in a room in the summer with no air conditioning. How does the temperature near the floor compare to the temperature near the ceiling? Why is this? Without buying an air conditioning unit, what way can you think of to equalize the temperature in the room?
7. From the reading “Mantle” by National Geographic, how does the Earth’s interior undergo convection?
8. From the reading “Cloud Formation” by the North Carolina Climate Office, How does convection produce clouds? Is there still convection going on even if no clouds form? Why?
9. From the reading “The Relationship Between Heat Transfer and Cooking” by Nora Fulmer, how are conduction, convection, and radiation important for cooking? What are some examples of cooking that use these methods of heat transfer?
10. Think of some of your favorite foods. How are conduction, convection, and radiation used to prepare them?
Unit 9: Waves, Sound, and Light

1. What types of mechanical waves have you experienced before? How about electromagnetic waves?
2. Some electromagnetic waves are dangerous to humans. Which are they? What is the property they have that makes them dangerous?
3. Imagine you are at the beach. What are examples of transmission, reflection, refraction, absorption, and diffusion going on around you?
4. At a baseball game, fans sometimes do “the wave,” in which audience members time raising their arms so that the movement propagates throughout the audience. How is this similar to the particles in a mechanical wave?
5. If you hold a seashell to your ear, you can hear the “ocean.” You can also hear this sound when you cup your hands around your ears. Where does this sound actually come from?
6. In forensic-fiction TV shows, plots are often driven by being able to manipulate a sound file to remove unwanted noise in order to isolate a particular sound. From what you know about analog and digital sound recording, how realistic is this?
7. From the reading “Why Do Elephants Bellow but Whales Squeak like a Mouse” by The Conversation, how do the sounds of large marine animals compare to those of large land animals? Why?
8. From the reading “Discovering the Electromagnetic Spectrum” by NASA, how was the ultraviolet light discovered? What was the experiment being performed, and what was the outcome expected?
9. From the reading “Feature Interview—Daniel Kish” by Susan Baldacci, how can humans use echolocation? What is it like, and what are the benefits? Would you like to be able to use echolocation like a bat does?
10. How does light behave like both a particle and a wave?
11. What is the order of colors in a rainbow? Why are these colors always in the same order?
12. From the reading “Auto-focus Smart Glasses with Liquid Lenses” by Jorika Moore, what is necessary to be considered a lens? What are the benefits of this kind of lens?
13. What are reflecting and refracting telescopes? What are the benefits and disadvantages of each?

Unit 10: Electricity and Magnetism

1. What are the differences between charging a substance using friction, conduction, and induction? What are some examples of each?
2. When you turn on a lightbulb, what causes the electric energy from the wires to become thermal energy in the bulb?
3. Have you ever felt a static shock? How did it happen? What are other ways static electricity can happen?
4. Why is the resistance of electron flow, or ohm, important for technology that uses an electric current? What are some examples?
5. What are the differences between series circuits and parallel circuits? What are the benefits and disadvantages of each? Which would you rather have in your home?
6. Are magnetic north and geographic north the same? Why or why not?
7. What devices use electromagnets? How can you increase the magnetic field of an electromagnet?
8. How are electricity and magnetism related? What evidence supports this?
9. From the reading "How Electricity Is Delivered to Consumers" by the U.S. Energy Information Administration, what needs to be considered in order to supply electricity to homes? How has this changed over time, and how may this change in the future?
10. From the reading “Earth’s Magnetosphere” by NASA, how does Earth’s magnetic field protect us from solar radiation? What would happen to Earth if it didn’t have a magnetic field?
11. From the reading “Animal Magnetism” by PBS, what are magnetic polar reversals? How do you think a polar reversal would affect our society?
12. From the reading “Animal Magnetism” by PBS, what are some examples of animals that use Earth’s magnetic field for navigation and orientation? Why would using the magnetic field, rather than other means, be useful for these animals?
13. From the reading "Hans Christian Oersted" by Famous Scientists.org, how did Oersted discover electromagnetism? What effect did this discovery have on the scientific community? Does anything surprise you about Oersted’s ideas, or the ideas of his contemporary scientists?
Edgenuity is pleased to provide an extensive course customization toolset, which allows permissioned educators and district administrators to create truly customized courses that meet the demands of the most rigorous classroom or provide targeted assistance for struggling students.

Edgenuity allows teachers to add additional content in two ways:

1. Create a brand-new course: Using an existing course as a template, teachers can remove content; add lessons from the Edgenuity lesson library; create their own activities; and reorder units, lessons, and activities.

2. Customize a course for an individual student: Change an individual enrollment to remove content; add lessons; add individualized activities; and reorder units, lessons, and activities.

Below is a quick-start guide for adding lessons from a different course or from the lesson library.
In addition to adding lessons from another course or from the lesson library, Edgenuity teachers can insert their own custom writing prompts, activities, and projects.
If you previously created new activities, they will display here. Click the activity name to preview the activity instructions.

Click the green plus sign to insert an activity into the lesson.

The activity will be inserted at the top of the unit. You can move the activity to another location in the lesson.

If you are creating a new Writing Prompt, specify the name, description, prompt, grade weight category, and optionally, keywords for scoring, sample answer, and scoring guidance.

If you are creating a new Project, specify the name, description, type, and grade weight category, and provide student resources by entering hyperlinks to web sites or uploading files.

NOTES

- Accepted file types are: .ppt, .pptx, .xls, .xlsx, .doc, .docx, .zip, .pdf, .accdb, .msg.
- Links you create won’t go through the Edgenuity Emissary (Proxy). This means that your IT department will need to ensure that the link is whitelisted or otherwise allowed to be accessed. It also means that items blocked by the Edgenuity proxy may be visible on the sites you link to. In addition, the Edgenuity tools to highlight, translate, read aloud, or add a sticky note will not be present on the sites you link to.
- You add activities to courses with no enrollments or on individual student’s courses. It is not possible to add activities to in-flight courses that have enrollments.
**UNIT 1: ATOMS AND THE PERIODIC TABLE**

**Additional Teaching Materials**

**The Structure of an Atom and its Particles**

This is a collection of 5E lessons (lessons that center on “Engage, Explore, Explain, Elaborate, and Evaluate”) on atomic structure and models. The lessons engage students by including hands-on features, such as building models out of clay, watching short videos, critical thinking, decision making, sharing of ideas between students, and having classroom discussions.

[http://www.cpalms.org/Public/PreviewResourceLesson/Preview/71593](http://www.cpalms.org/Public/PreviewResourceLesson/Preview/71593)

**Just How Small is an Atom?**

A brief, five-and-a-half-minute video discussing the size of an atom, the nucleus, and the electron cloud using comparisons that are easier to understand than 2-D models. It helps students more easily and accurately visualize the structure of an atom.


**Additional Readings**

*Here is a Photo of a Single Atom*

This is a *Popular Mechanics* article by Avery Thompson discussing a photograph of a strontium atom that was taken by PhD student David Nadlinger and won the 2018 Engineering and Physical Sciences Research Council science photography competition. The strontium atom could be photographed because of its relatively large size (the nucleus contains 38 protons), increased electron activity due to high-powered lasers, and a long exposure time.


*Atomic Structure (Great Ideas of Science)*
This 2007 book, written by Rebecca L. Johnson, explains atomic structure and the history of atomic theory, including electrons, radioactivity, neutrons, quarks and other particles, and the Standard Model.¹

**Madame Curie: A Biography**

This book is about Marie Skłodowska Curie (1867–1934), the first woman scientist to win worldwide acclaim and, indeed, one of the great scientists of the 20th century. Written by Curie’s daughter, the renowned international activist Eve Curie, this biography chronicles Curie’s legendary achievements in science, including her pioneering efforts in the study of radioactivity and her two Nobel Prizes in Physics and Chemistry. It also spotlights her remarkable life, including her childhood in Poland, her storybook Parisian marriage to fellow scientist Pierre Curie, and her tragic death brought on by the very radium that brought her fame. Now updated with an eloquent, rousing introduction by bestselling author Natalie Angier, this timeless biography celebrates an astonishing mind and an extraordinary woman’s life. It was published in 1985.²

**Madame Curie’s Passion**

This 2011 *Smithsonian* article written by Julie Des Jardins discusses Marie Curie’s life, her accomplishments in chemistry, and the concerns she faced as a woman in science during the early 1900s. It is a fascinating read that makes Curie both personable and relatable, and highlights why her scientific contributions are important to science as well as societal reform during the 20th century.

[https://www.smithsonianmag.com/history/madame-curies-passion-74183598/](https://www.smithsonianmag.com/history/madame-curies-passion-74183598/)

**4 New Elements Are Added to the Periodic Table**

Four new elements are reported in this 2016 NPR article by Bill Chappell. The article shows that the periodic table is still being revised, and explores the scientific goals and current difficulties in discovering new elements. The article includes the classification of “superheavy” elements and how this affects atom stability.


**Four New Names Officially Added to the Periodic Table of Elements**

This 2016 *New York Times* article by Nicholas St. Fleur explains how the four new elements from the reading “4 New Elements Are Added to the Periodic Table” have received official names.


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² [https://smile.amazon.com/Madame-Curie-Biography-Eve/dp/0306810387/ref=sr_1_3?ie=UTF8&qid=15323220204&sr=1-3&keywords=marie+curie](https://smile.amazon.com/Madame-Curie-Biography-Eve/dp/0306810387/ref=sr_1_3?ie=UTF8&qid=15323220204&sr=1-3&keywords=marie+curie)
UNIT 2: STATES AND PROPERTIES OF MATTER

Additional Teaching Materials

States of Matter

This interactive virtual simulation is designed for students to manipulate and observe state changes by adjusting temperature, pressure, and volume. Students also observe how individual molecules interact and bond during phase changes.

https://phet.colorado.edu/en/simulation/states-of-matter

A Matter of State (Video: 28 min 40 sec)

Matter is examined in its three principal states—gas, liquid, and solid—in this video that relates the visible world to the submicroscopic.

http://www.learner.org/vod/vod_window.html?pid=797

Surface Tension of Water

This lesson plan (pages 14–15 of the Water Basic Lesson Plan) provides teacher guidelines for using 3-D water and ethanol molecule models to explain water’s surface tension property that results from the polar nature of the molecules by comparison with non-polar molecules. The lesson is initiated by having students observe phenomena related to surface tension and then use 3-D molecules to model the behavior. The water kit required for this activity is available on loan for free from the Milwaukee School of Engineering Center for BioMolecular Modeling (http://cbm.msoe.edu/teachRes/library/) or for purchase from 3-D Molecular Designs.


Additional Readings

The Sand-Reckoner: A Novel of Archimedes

In this 2001 novel by Gillian Bradshaw, the young scholar Archimedes had the best three years of his life at Ptolemy’s Museum at Alexandria. To be able to talk and think all day, every day, sharing ideas and information with the world’s greatest minds, is heaven to Archimedes. But heaven must be forsaken when he learns that his father is ailing, and his home city of Syracuse is at war with the Romans. Reluctant but resigned, Archimedes travels home to find a job building catapults as a royal engineer. Though Syracuse is no Alexandria, Archimedes also finds that life at home isn’t as boring or confining as
he originally thought. He finds fame and loss, love and war, wealth and betrayal—none of which affects him nearly as much as the divine beauty of mathematics.

**New Form of Water, Both Liquid and Solid, Is ‘Really Strange’**

In 2018, a form of water was discovered in which the oxygen atoms remain rigid in a lattice, like a solid, but the hydrogen atoms move freely between them, like a liquid. This form of water is called superionic, and occurs under high pressure and temperature after the molecular bonds have broken.


**This Simple Demo Explains Solid, Liquid, and Gas**

This article, written by Jay Bennett in 2016, also contains a great video for students. The article and video discuss the movement of individual particles in a state of matter and how the movement of particles changes as matter changes state. In the video, Cambridge mathematician Tadashi Tokieda demonstrates this principle by adding progressively more cedar balls to a moving dish to show changes in the movement of the balls. For example, three balls, which represents a gas, will move in the direction that the bowl is moving. However, seven balls, which represents a liquid, move in the opposite direction, and slowly adding balls from three to seven shows how particles move during a phase change.

https://www.popularmechanics.com/science/a22343/numberphile-phase-changes/

**What the Heck Is ‘Ice VII,’ and Why Are Scientists Using Lasers to Make It?**

This article, written by Mary Beth Griggs in 2017, examines a particular type of ice that so far has only been formed on Earth using powerful X-ray lasers. Students learn that ice, although well-known as the solid form of water, can have different physical properties based on certain conditions during the phase change. Normally, this type of ice is produced in outer space during planetary collisions, and may be found on distant planetary bodies such as Europa.

https://www.popsci.com/ice-vii-lasers

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UNIT 3: CHEMICAL BONDING AND COMPOUNDS

Additional Teaching Materials

Chemical Bonds (Video: 28 min 39 sec)

This video highlights the differences between ionic and covalent bonds, offering a thorough explanation using scientific models and real-world examples from nature.

http://www.learner.org/vod/vod_window.html?pid=800

Atoms and Bonding

This simulation exercise involves students building model atoms. These detailed models are then combined in different variations demonstrating ionic or covalent bonds.

http://www.classzone.com/cz/books/bio_07/resources/htmls/animated_biology/unit1/bio_ch02_0059_ab_atombond.html

Additional Readings

Chemists Find a New Chemical Bond

This article by Fracie Diep details a new chemical bond discovered in 2014. This chemical bond is called a vibrational bond. It occurs between two heavy atoms with a hydrogen atom in the middle, and increases the potential energy of the system.


Scientists Invent a Liquid With Holes In It

In 2015, a new liquid was designed with holes, appearing like a liquid sponge. This article explains this new liquid and why it appears like a sponge. The unusual feature is due to the chemical structure of the compound, which forms a “cage” of carbon, hydrogen, and oxygen, and leaves an air pocket within the cage that the other molecules cannot enter.


Rosalind Franklin and DNA

Rosalind Franklin’s research was central to the discovery of the double-helix structure of DNA. She never received the credit she was due during her lifetime. In this classic work, Anne Sayre, a journalist and close friend of Franklin, puts the record straight. This work was published in 2000.

https://smile.amazon.com/Rosalind-Franklin-DNA-Anne-Sayre/dp/0393320448/ref=sr_1_2?ie=UTF8&qid=1532916945&sr=1-2&keywords=Rosalind+Franklin+and+DNA
DIHYDROGEN MONOXIDE: UNRECOGNIZED KILLER

This article, written in 1997, discusses the chemical dihydrogen monoxide and its dangers, and shows that many people do not realize that dihydrogen monoxide is just the chemical name for water.

https://www.washingtonpost.com/archive/opinions/1997/10/21/dihydrogen-monoxide-unrecognized-killer/ee85631a-c426-42c4-bda7-ed63db993106/?noredirect=on&utm_term=.16a786a0cd9f
UNIT 4: CHEMICAL REACTIONS

Additional Teaching Materials

Chemical Reactions and Stoichiometry

This series of interactive simulations provides students with the ability to experiment with reaction concentration and temperature to observe the effects on a chemical reaction. This simulation is coupled with questions that lead students to develop a conceptual understanding about how these factors affect reaction rates. This review focuses only on the Day 1 activities within the site, accessed on pages 1–5. In this portion of the lesson, students are directed to explore investigations by accompanying text, questions, goals, and specific challenges. The variables of temperature and concentration are addressed separately, and then the student is asked to manipulate both variables together with the size of the container in the end challenge. Simulations can be paused for closer investigation, reset, and replaying numerous times. Multiple-choice and short-response questions can be saved and sent in a report to the teacher. The simulations do not reference specific temperatures, but ranges qualitatively from low to high.

https://learn.concord.org/resources/113/chemical-reactions-and-stoichiometry

Exothermic Reactions Explained (Video: 3 min 21 sec)

Using potassium permanganate and glycerol, Professor Mike Canestro performs a complete exothermic reaction demonstration with a chemical explanation.

https://www.pbs.org/video/exothermic-reactions-explained-xqpw3o/

Additional Readings

Reading Expeditions (Science: Physical Science): Chemical Changes

Chemical changes occur throughout nature and living things. Students can learn to identify chemical changes and the signs that they have occurred. Then, students explore how these remarkable reactions shape their everyday lives. The student will learn to identify chemical changes and the signs that they have occurred. This work introduces how to distinguish between physical and chemical changes, and the concept that chemical reactions involve changes in energy. This work also identifies factors that affect reaction rate, explains the role of enzymes in chemical reactions, and describes the importance of chemical reactions in daily life. It was written by Rebecca L. Johnson and published in 2014.

5 https://smile.amazon.com/Reading-Expeditions-Science-Physical-Chemical/dp/0792245830/ref=sr_1_1?ie=UTF8&qid=1532913082&sr=8-1&keywords=national+geographic+chemical+changes

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When the Water Turned Brown

This article, written by Abby Goodnough, Monica Davey, and Mitch Smith in 2016, discusses the Flint River crisis in Flint, Michigan, and how an excess of chlorine corroded the lead pipes, introducing lead molecules into the water. The article further discusses the signs that something was wrong with the water, how the city insisted the water was safe, and the repercussions of poor city management.


The Chemical Reaction That Cleans Everything

This article from 2017 explains the chemistry behind the ability of bleach to remove stains. As students are most likely already familiar with bleach, this article provides a common, household example of a chemical reaction.


Alfred Nobel: Inventive Thinker

This book discusses the life and work of Alfred Nobel, a Swedish inventor who developed dynamite and instituted the Nobel Prize. Born in Stockholm, Sweden, Alfred Nobel is widely known as the founder of the Nobel Prizes. He was also a successful inventor who made great advances in the field of explosives. During his early years, he and his family struggled to make ends meet after his father’s business ventures left them bankrupt. Nobel excelled through his education. He began to put his curious, inventive mind to work, experimenting with nitroglycerin. Tragedy struck the Nobel family in 1865 when his brother, Emil, was killed in an explosion at their explosives factory. One year later, Nobel invented dynamite, a safer explosive. In his later years, his thoughts turned from creating better explosives to bringing the world closer. He decided to use much of his fortune to create the Nobel Prizes, awards given to individuals or groups for making advancements in their fields. This book was written by Tristan Boyer Binns. Book jacket.

6 https://smile.amazon.com/Alfred-Nobel-Inventive-Thinker-Stories/dp/0531123286/ref=sr_1_1?dchild=1&keywords=Alfred+Nobel+inventive+thinker&s=books
UNIT 5: MIXTURES, SOLUTIONS, AND ACID-BASE REACTIONS

Additional Teaching Materials

Acid or Base???

In this hands-on lesson, students differentiate between household acids and bases by observing physical properties and by testing for pH. This is a good lesson to provide after the lesson Lab: Acids and Bases, as it enhances skills developed from the previous lab regarding pH and encourages students to use their knowledge of the physical characteristics of acids and bases in their identification.

http://www.cpalms.org/Public/PreviewResourceLesson/Preview/61620

Red Alert!

This lesson enhances the students’ understanding of temperature’s effect on solubility. The teacher adds red food dye to bleach and shows how increasing the concentration of dye or increasing the temperature of the bleach affects solubility. This reaction is not instantaneous, and so teaches students that some reactions can take time to occur. This lesson would ideally follow the lesson Solubility, which explains that temperature influences the solubility of a substance.


Additional Readings

What is Acid Rain?

This 2009 article by National Geographic explains acid rain, how it is formed, and some of the negative effects it has on the environment, as well as what humans can do to prevent or mitigate it. This article is best read after the lesson Properties of Acids and Bases, as this lesson introduces acids and their particular characteristics.


An Ingenious 20-Cent Paper Centrifuge Could Save Lives from Malaria

Making technology available to economically impoverished areas is an ongoing field of research. This 2017 article by Rosalie Chan discusses the importance of a centrifuge in separating the constituents of blood, and how a simple and inexpensive version of the device can be used to achieve the same result. Because this article discusses advancements in technology concerning the separation of blood, it is best read and discussed after the lesson Separation of Mixtures.

https://www.inverse.com/article/26231-paper-centrifuge-save-lives-malaria
Sunlight-powered purifier could clean water for the impoverished

This article, written by Robert Service in 2017, is another example of technology being made available to economically impoverished areas. In this case, an inexpensive water purifier can use the evaporation of polluted water to make clean drinking water. This article is best paired with the article “A cardboard centrifuge separates blood cells from plasma,” and read after the lesson Separation of Mixtures.


What is Ocean Acidification?

This article by the National Ocean and Atmospheric Association discusses how the oceans are becoming more acidic as well as the effects this has on ocean biology, specifically the creatures that use calcium in their bodies. This is a good reading following the lesson Acids and Bases in Solution, as it discusses pH and the effects of acids on carbonates.

https://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F
UNIT 6: MOTION AND FORCES

Additional Teaching Materials

BBC Video on the Hammer and Feather Drop on the Moon

This historic 50-second video shows astronaut David Scott dropping a geologic hammer and a feather on the moon, providing conclusive evidence that Galileo’s idea that objects of different weights can fall at the same speed. This video could be shown during the lesson Gravity, as it demonstrates the impact of air resistance on an object, as the area surrounding the moon is a vacuum.

https://www.bbc.co.uk/programmes/p052jb41

Falling for Gravity

This lesson explores the motion of objects in freefall using their displacement over time. Students then calculate the average velocity and acceleration of these objects and graph them in a velocity-versus-time graph. This lesson is best used after the lesson Acceleration to further students’ understanding of the material up to this point.

http://www.cpalms.org/Public/PreviewResourceLesson/Preview/51224

Additional Readings

Isaac Newton: A Life From Beginning to End

Isaac Newton seemed to be a most unwanted child of the world. Ignored by his mother, scorned by contemporaries, seemingly at war with the world in which he lived, Newton turned his energies to things unseen. His laws of motion and law of universal gravitation would set the stage for a most extraordinary life. Published in 2017 by Hourly History, this book takes a more in-depth approach to Newton and puts his accomplishments in light of his life history, turning him into a relatable and human character rather than just a name discussed in science class. Could pair very nicely with the lesson Newton’s Laws of Motion to give students a more three-dimensional look at this amazing scientist.  

The Strange, Deadly Effects Mars Would Have on Your Body

Kevon Fong discusses how gravity has influenced our bodies and the deleterious effects that living in a different gravity for long periods could do. Written in 2014, this article takes an interesting look at gravity and how it shapes humanity at the anatomical level. This article could work well with the lesson Gravity, as it shows that gravity is more than the force that gives objects weight.

https://www.wired.com/2014/02/happens-body-mars/

Physics and the Automotive Industry

This article, written by Matthew Sill, discusses how many of the concepts discussed in this unit relate to the automotive industry and how modern-day car manufacturers design cars to be fast and safe. The article mentions the numerous considerations of car manufacturers and how many of the equations from the lessons are used to make the best-performing vehicles. Because the article discusses force, mass, acceleration, velocity, and momentum, this may be a good read following the Momentum lesson to tie together many of the concepts using an interesting and relatable topic.

http://ffden-2.phys.uaf.edu/211.web.stuff/sill/
UNIT 7: WORK, POWER, AND ENERGY

Additional Teaching Materials

Bouncy Energy

This lesson enhances the students’ understanding of energy transformations using a bouncy ball. Students predict whether the bounce is elastic or inelastic and make observations about the behavior of the ball and its release of energy. Students record bounce height and calculate the speed of the ball immediately before and after making contact with the floor. This lesson provides a fun, hands-on experience that enables students to practice what they have learned and further their understanding of energy. This lesson could follow Introduction to Energy as an introduction into the transformation of energy, or it could follow Potential and Kinetic Energy to enhance student understanding of energy transformations.

http://www.cpalms.org/Public/PreviewResourceLesson/Preview/36984

Segment 4H: Conservation of Energy (Video: 8 min 16 sec)

This video looks at the process of creating electric energy from a dam. The video discusses conservation of energy, kinetic energy, gravitational potential energy, velocity, friction, and energy calculations, and provides an interesting, real-world example to the lessons studied in this unit. Ideally, this video should be shown after the lesson Energy Transformations so that students understand all of the terms mentioned in the video, but can be used as an introduction to some of the terms.


Additional Readings

How A Nuclear Reactor Works

This article, from the Nuclear Energy Institute, contains detailed information about how nuclear energy is used to produce electricity. Details are also included about the type of reactors used in the United States and how new technology is impacting the use of nuclear energy. Two videos are also featured showing how boiling-water reactors and pressurized water reactors, the two most common types of reactors in the United States, actually work and produce energy. This is an excellent article to read after the lesson Energy Transformations, as it goes into more depth on nuclear reactions and how humans harness nuclear energy.

https://www.nei.org/fundamentals/how-a-nuclear-reactor-works
**Solar System Exploration**

This article written by NASA discusses how the sun creates energy. The article also contains many pictures of the sun in action. Furthermore, there is a list of facts further detailing nuclear fusion and how it powers the sun. This is a good article to read after the lesson Energy Transformations and alongside the reading “How a Nuclear Reactor Works,” as it makes a nice comparison of the two types of nuclear energy.

[https://solarsystem.nasa.gov/solar-system/sun/overview/](https://solarsystem.nasa.gov/solar-system/sun/overview/)

**World of Change: Global Temperatures**

This NASA article discusses the rise of global temperature over the last century and what this could mean for the future. This is a good article to read after the lesson Earth’s Energy Budget, as it goes into more detail about greenhouse gases and the effect of increased absorption of solar radiation, as well as provides detailed graphs that provide the information in an easy-to-understand way for students.

[https://earthobservatory.nasa.gov/WorldOfChange/decadaltemp.php](https://earthobservatory.nasa.gov/WorldOfChange/decadaltemp.php)
UNIT 8: THERMAL ENERGY AND HEAT

Additional Teaching Materials

Heat Transfer Demonstrations (Video: 3 min 36 sec)

This video discusses some ways the teacher can demonstrate heat transfer in class to students. One example shows the effect of radiation on an ice cube, and another uses food coloring to show the movement of cold and hot water. The demonstrations can be spread out through the unit to show the effects and differences of conduction, convection, and radiation.

http://www.cpalms.org/Public/PreviewResourcePerspectivesVideo/Preview/128373

Oceans and Energy Transfer (Video: 2 min 51 sec)

This video introduces Georges Weatherly, a former professor of oceanography specializing in ocean currents. Weatherly discusses how conduction, convection, and radiation all play an important part in the movement and behavior of water, going into detail about the role of convection. This video would be good to play after the lesson Convection to stress the importance of convection in ocean currents.

http://www.cpalms.org/Public/PreviewResourcePerspectivesVideo/Preview/128501

Additional Readings

The Relationship between Heat Transfer and Cooking

This article by Nora Fulmer discusses conduction, convection, and radiation in cooking and provides examples of how each are used, along with helpful .gif-type images. This reading could be assigned after the lesson Heat as an introduction to the different methods of heat transfer, or could be read after the lesson Radiation.

https://www.webstaurantstore.com/blog/postdetails.cfm?post=976

Cloud Formation

This article by the North Carolina Climate Office provides further insight into what convection is, how it forms clouds, and the effects of temperature and pressure on convection. It also explains how convection can happen but result in no clouds forming. This reading is recommended after the lesson Convection.

https://climate.ncsu.edu/edu/CloudFormation
Mantle

This National Geographic article goes into detail about Earth’s mantle, including the role of convection in the movement of rock. At the end, the article introduces the role of seismic waves generated by earthquakes, which is a topic that will be addressed in a later unit and can be revisited. This reading is recommended to follow the lesson Convection.

https://www.nationalgeographic.org/encyclopedia/mantle/

Strange Glow: The Story of Radiation

Timothy Jorgensen introduces key figures in the story of radiation—from Wilhelm Roentgen, the discoverer of X-rays, and pioneering radioactivity researchers Marie and Pierre Curie, to Thomas Edison and the victims of the recent Fukushima Daiichi nuclear power plant accident. Tracing the most important events in the evolution of radiation, Jorgensen explains exactly what radiation is, how it produces certain health consequences, and how people can protect themselves from harm. He also considers a range of practical scenarios, such as the risks of radon in basements, radiation levels in the fish people eat, questions about cell phone use, and radiation’s link to cancer. Jorgensen empowers people to make informed choices while offering a clearer understanding of broader societal issues. Published in 2017.

UNIT 9: WAVES, SOUND, AND LIGHT

Additional Teaching Materials

Wave Machine (Video: 3 min 52 sec)

In this video, Alom Shaha discusses how to build a simple, inexpensive wave machine for a class. This video is meant for teacher use to either build a wave machine before a lesson or to have students work together to build it during a lesson. The wave machine is composed of masking tape, kebob sticks, and gummy candies, and students observe how a wave propagates, observing the wave amplitude, wavelength, and frequency. Change in speed through different media can also be simulated by removing the gummy candies from one side of the machine.

http://www.cpalms.org/Public/PreviewResourceLesson/Preview/24349

Doppler Effect

In this lesson, students learn about the Doppler Effect by using a tuning fork. Students tie a string around a tuning fork, hit the fork, and then swing it around their heads to hear changes in frequency as the fork spins around them. This lesson could be introduced during or after the lesson Properties of Sound, after the Doppler Effect has been explained.

http://nsdl.oercommons.org/courses/doppler-effect-2/view

Additional Readings

Sound Waves

This article, written for the University of Southampton, goes more in depth on the propagation of transverse waves through matter and the movement of particles in a wave. The article contains two helpful gif images that show how particles move in a wave and how the observed compression and rarefaction of particles in a fluid corresponds to a traditional wave. This reading is best introduced during the lesson Sound Waves.

https://blog.soton.ac.uk/soundwaves/wave-basics/the-nature-of-waves/

Why Do Elephants Bellow but Whales Squeak like a Mouse?

This article, written for the Conversation in 2016, explores how large land animals tend to make deep sounds, whereas large marine animals tend to be more high-pitched sounds. The reason for the difference is because marine animals must utilize the way sound travels through water instead of air. The article contains interesting points about frequency and features sound clips of multiple animals, showing differences in pitch. Best read after the lesson Properties of Sound.

**Feature Interview—Daniel Kish**

This article, written by Susan Baldacci in 2015, discusses Kish’s remarkable ability to use echolocation to “see”. Kish, blind since he was one year old, taught himself echolocation as a child as a means to navigate his surroundings. Kish uses short clicks of his tongue to make sounds that reflect off of surrounding objects, which forms a “three-dimensional fuzzy geometry” in his mind. This article is recommended after the lesson Using Sound, as it introduces another wonderful way that humans can use sound in their environment.


**Discovering the Electromagnetic Spectrum**

This NASA article written in 2013 describes the serendipitous discovery of ultraviolet light, as well as the subsequent discoveries of infrared, X-ray, and gamma radiation. Humans’ knowledge of the electromagnetic spectrum was gained through the discoveries of many scientists over the last 200 years, as this article shows. It also contains a photograph of the very first X-ray ever taken. This reading is recommended after the lesson The Electromagnetic Spectrum.


**Auto-Focus Smart Glasses with Liquid Lenses**

This 2017 article by Jorika Moore discusses the advent of a “liquid lens” that is both affordable and adjustable. The lenses have the capacity to autofocus on an object in just 14 milliseconds, and the prescription can be changed as easily as using a Smartphone app. This reading could be read after the lesson Refraction and Lenses to discuss what is necessary to be considered a lens and how technological advancements allow the production of an inexpensive alternative to normal glasses.

UNIT 10: ELECTRICITY AND MAGNETISM

Additional Teaching Materials

Circuit Construction Simulation

This lesson focuses on how to construct working circuit systems using a free downloadable virtual simulator. Students use Ohm’s law to construct series and parallel circuits using resistors, light bulbs, batteries, and switches and enhance their understanding of open and closed circuits. Best introduced during or after the lesson Electric Circuits.


Levitation Engineers: Exploring Forces

In this lesson, students observe and explore the behaviors of magnets by performing experiments with magnets and contact and noncontact forces. At the end, students utilize their engineer skills to design a magnetic levitation device. The lesson includes a downloadable lesson plan and student worksheet. Best introduced during or after the lesson Magnets and Magnetism.

http://science4inquiry.com/LP_Levitation.php

Additional Readings

How Electricity Is Delivered to Consumers

This article by the US Energy Information Administration explores how electricity is generated in power plants and transported to consumers via transmission and distribution lines. The article delves into who develops electricity, how it is delivered, and how the power grid has changed over time. After reading this article, students become more familiar with where their own electricity is generated and distributed and see how this system may change in the future.


Earth’s Magnetosphere

This NASA article takes a more in-depth look at Earth’s magnetic field. Students learn that the magnetic field is crucial for more than providing electromagnetism; it is necessary for life to exist on Earth. The article compares Earth to Mars and discusses how Earth’s atmosphere would be stripped away by solar winds if it did not receive protection from the magnetic field.

https://science.nasa.gov/science-news/news-articles/earths-magnetosphere
**Animal Magnetism**

This PBS article, written by Peter Tyson in 2003, takes a further look at how many animals navigate and orient themselves using Earth’s magnetic field and how the eventual magnetic polar reversal may affect them. Students investigate the concept of polar reversals and further understand the way animals and other organisms—including sea turtles, birds, blind mole rats, hamsters, fish, whales, and even bacteria—sense Earth’s magnetic field.

[http://www.pbs.org/wgbh/nova/nature/magnetic-impact-on-animals.html](http://www.pbs.org/wgbh/nova/nature/magnetic-impact-on-animals.html)

**Ferrofluid—it’s Shiny, Metallic and Ridiculously Fun to Watch in Action**

This article, written by Umair Hussaini in 2017, focuses on ferrofluid and describes what it is, how it works, and what it is used for. After reading, students have a greater understanding of ferrofluid and its important contribution to science. The article also contains very interesting gif images of moving ferrofluid and a video. It ends with a recipe for how to make ferrofluid at home.

[https://www.technobyte.org/interesting-facts/ferrofluid-shiny-metallic/](https://www.technobyte.org/interesting-facts/ferrofluid-shiny-metallic/)

**Hans Christian Oersted**

This article, written for the site Famous Scientists, discusses the life of Hans Christian Orested and his discovery of electromagnetism. By reading this article, students gain a further understanding of how this discovery was made and its impact at the time by looking at who Orested was, what his thoughts on science were, and putting his life in context with other scientists and discoveries of the time.

[https://www.famousscientists.org/hans-christian-oersted/](https://www.famousscientists.org/hans-christian-oersted/)
Students engage in writing activities regularly throughout the course. Rubrics for assessment are available for both students and teachers. Different modes of writing are incorporated in student activities. The following prompts provide opportunities to respond in a variety of narrative/procedural, informative/expository, and argumentative writing modes.

**Writing Prompts**

**Unit 1: Atoms and the Periodic Table**

1. Discuss three of the atomic models, including the pros and cons of each and their scientific importance through history. Write an argument for the model you think is the most historically significant.
2. The study of atoms has a very long history. Discuss the significant advancements in atomic structure and the periodic table of elements in the past century. Explain how new elements are still being discovered and provide ways they differ from elements easily found on Earth.

**Unit 2: States and Properties of Matter**

1. Explain how particles move in solids, liquids, and gases and during state changes. Include descriptions of each way that matter can change its state and how these changes occur.
2. Archimedes discovered how to find the density of an irregular solid. Who was Archimedes and how was he important to science?

**Unit 3: Chemical Bonding and Compounds**

1. Explain the benefits and negatives of polymerization. Additionally, describe how our “throw away culture” affects the environment in regards to both natural and synthetic polymers.
2. Compare and contrast ionic, covalent, and metallic bonds. Use the periodic table to further explain the similarities and differences between each bond.

**Unit 4: Chemical Reactions**

1. Describe how a chemical equation is necessary to understanding a chemical reaction. Include the importance of balanced vs. unbalanced equations in your answer.
2. From the reading on Flint, Michigan, argue why cities need to be aware of chemical reactions in the environment and explain what steps can be taken to prevent unwanted reactions from occurring. Find additional sources to support your answer.
Unit 5: Mixtures, Solutions, and Acid-Base Reactions

1. Describe the physical and chemical differences between acids and bases and explain what makes an acid or a base weak or strong. Name some examples of weak and strong acids and bases and describe where they are used and what they are used for.
2. Identify and describe each method used to separate mixtures and provide at least two examples of mixtures each method is used for. Determine whether the provided mixtures are homogenous, colloids, or suspensions. What makes each separation method ideal to separate each provided mixture?
3. From the readings “What Is Acid Rain?” and “What Is Ocean Acidification?” explain the effects of acidic water on the environment and discuss ways to prevent these effects.

Unit 6: Motion and Forces

1. Think about your day yesterday from when you woke up to when you went to bed. In chronological order, narrate the different forces you experienced throughout your day. Consider Newton's laws of motion in your answer.
2. Car manufacturers want to design cars that are fast but also safe, as these features are generally high selling points to consumers. Choose a type of car and discuss how it was engineered using ideas from this unit and the reading “Physics and the Automotive Industry.” Make sure to discuss different equations from the lessons in your answer.

Unit 7: Work, Power, and Energy

1. List and describe eight different types of energy, including what causes them and how humans utilize these forms of energy.
2. Describe five renewable and five nonrenewable resources. What are the benefits and disadvantages of each resource? Choose one or two resources and argue why they should be used instead of the others to create energy.
3. Explain what greenhouse gases are and how they affect life on Earth. Discuss both benefits and disadvantages of greenhouse gases in your answer.

Unit 8: Thermal Energy and Heat

1. Describe the similarities and differences between how convection works below Earth’s surface, in the ocean, and in the atmosphere. Provide specific examples in your answer.
2. Describe the three forms of heat transfer, including the process each form uses to transfer heat. Explain what physical factors influence the transfer, absorption, and reflection of heat and provide three examples of how people have engineered ways to utilize heat transfer.
Unit 9: Waves, Sound, and Light
1. Describe some examples of analog and digital sound technologies. Explain the difference between the two and provide some benefits and disadvantages of each.
2. Think about looking in a normal mirror, a concave mirror, and a convex mirror and write a narrative about what you see. Explain how the reflection of light affects what the mirror shows.
3. Explain how the shape of a lens affects the refraction of light. Provide examples in your answer.

Unit 10: Electricity and Magnetism
1. What are the steps involved in creating an electromagnet? Describe each step, including the changes in electricity and/or magnetism.
2. Describe amperes, volts, and ohms, how they relate to each other, and how each are useful in the manufacture of electrical objects.
**STUDENT WRITING SAMPLES AND RUBRICS**

Edgenuity understands that students often find it difficult to understand assessment criteria and what represents “quality” work in a given writing mode. A useful teaching strategy to help students understand the nature and characteristics of quality writing in the different modes is to analyze and discuss exemplar student work prior to students tackling their own related task. Teachers may be reluctant to show exemplar writing assignments that exactly match the given task for fear that students may rely too heavily on these exemplars or that students will assume there is an expected answer. However, Edgenuity has provided the following recommended resources that contain multiple exemplars of the different writing modes that can be used to further writing instruction.

Common Core Appendix C Writing Sample with Annotations

http://www.corestandards.org/assets/Appendix_C.pdf

Achieve the Core Writing Samples with Annotations

https://achievethecore.org/category/330/student-writing-samples

In addition to the above annotated exemplars, Edgenuity has provided the following argumentative, informative, and narrative student writing samples. These deliberately flawed samples can be used in the teaching of writing workshops as a guide for students’ writings of varying ability levels.
Narrative/Procedural Writing Student Sample

This student exemplar serves to provide teacher guidance regarding the lab report students will write in the lesson Electric Charge.

Assignment summary: Conduct an investigation to explore the number of electrons transferred to a balloon as a result of generated static electricity. This investigation will allow you to determine the number of electrons transferred from fur or wool to a pair of charged balloons. Using vector diagrams, trigonometry, algebra, and the fundamental forces of the universe, you can calculate how many electrons were transferred to each balloon under each set of conditions. To find the number of electrons transferred, you will need to know the total charge on the system and divide it by the charge of a single electron.

Coulomb's Law

Purpose:
The purpose of this lab is to find out the number of electrons transferred to a balloon using static electricity.

Brief overview:
This experiment will test the number of electrons transferred through generated static electricity and will require calculations using the total charge of the system and the charge of a single electron.

Materials:
2 balloons, protractor, balance, fur, string, compass, wool, and 2 paperclips

Procedure:
1. Find the mass of the balloon using the balance. Convert grams to kilograms and record the mass in the data table.
2. Blow up 2 balloons so each has a diameter of about 4 inches and tie knot. Then tie a 1-meter piece of string to the end of each balloon.
3. Hang the balloons from the ceiling using the paperclip. Each balloon should be 1 meter from the next.
4. In data table B, draw the system for the balloon using force diagrams.
5. Rub each balloons ten times with the fur. Make sure the balloon doesn’t touch anything else.
6. Draw the system and measure the angle between the balloons. Record this in your drawing.
7. Draw a force diagram of the system and label force of gravity, electromagnetic force, and tension force.
8. Use Newton’s second law to calculate the force of gravity. Record in data table A.
9. Draw a distance vector triangle and calculate the distance.

10. Write an equation for the total charge and calculate the total charge. Then calculate the total electrons.

11. Repeat steps 5–10 using 20 rubs of fur.

12. Repeat steps 5–10 using 20 rubs of wool.

Data

Table A

<table>
<thead>
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<th>.012kg</th>
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<tbody>
<tr>
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<tr>
<td>Force of Gravity</td>
<td>0.12N</td>
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</table>

Table E

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<th>Material</th>
<th>Number of Rubs</th>
<th>Resulting Angle</th>
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<tbody>
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<td>Fur</td>
<td>10</td>
<td>5 degrees</td>
</tr>
<tr>
<td>2</td>
<td>Fur</td>
<td>15</td>
<td>10 degrees</td>
</tr>
<tr>
<td>3</td>
<td>Fur</td>
<td>20</td>
<td>25 degrees</td>
</tr>
<tr>
<td>4</td>
<td>Wool</td>
<td>10</td>
<td>10 degrees</td>
</tr>
<tr>
<td>5</td>
<td>Wool</td>
<td>15</td>
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<td>30 degrees</td>
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</table>

Table F

<table>
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<th>Number of Rubs</th>
<th>Number of electrons transferred</th>
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</thead>
<tbody>
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<td>Fur</td>
<td>10</td>
<td>1.9x10^6</td>
</tr>
<tr>
<td>2</td>
<td>Fur</td>
<td>15</td>
<td>1.2x10^7</td>
</tr>
<tr>
<td>3</td>
<td>Fur</td>
<td>20</td>
<td>1.0x10^8</td>
</tr>
<tr>
<td>4</td>
<td>Wool</td>
<td>10</td>
<td>1.2x10^7</td>
</tr>
<tr>
<td>5</td>
<td>Wool</td>
<td>15</td>
<td>1.0x10^8</td>
</tr>
<tr>
<td>6</td>
<td>Wool</td>
<td>20</td>
<td>4.7x10^8</td>
</tr>
</tbody>
</table>

Analysis

The number of electrons increased with the number of rubs for both materials. This makes sense because as the balloon is rubbed, it picks up electrons from the material. As the angle increased, so did the number of electrons. Electrons increase the electrical force, which pushes the balloons away from
one another. This also increases the angle. Another pattern was that the wool transferred more electrons than the fur. This could be because the wool gives away electrons easily.

**Conclusion**

This experiment showed the relationship between material and number of electrons and the relationship between number of rubs and electrons. As the number of rubs increased, the number of electrons increased. This was observed by seeing a greater force pushing the balloons apart. More electrons increased the charge between the two balloons, which increased the force. This lab also showed that wool is more likely to give up electrons than fur. This is supported by the data in tables E and F because the wool trials had more electrons than the fur trials.

A few errors may have affected this experiment. First, even though the number of rubs was counted, they may have not been of the same size. This could alter the number of electrons picked up by the balloon. Another error could have been in the calculations. This would have caused an error in the final number of electrons counted for each trial. The last error could have been when the air conditioning was turned on in the classroom and started to push the balloons around slightly. This would have added another force to the system and could have changed our calculations for the electrical force. To improve this experiment, do more trials and make sure the air conditioning is off. Another improvement could be to test other materials, like different fabrics.
Expository/Informative Writing Student Sample

This student exemplar serves to provide teacher guidance regarding the project response in the lesson Periodic Table.

Assignment summary: In this assignment, you will research an element of your choice from the periodic table. Using reference materials and Internet sites, you will collect information about the element. Useful references for gathering this information are listed at the end of this document. You will then present your findings in a multimedia presentation, which should include seven slides: a title slide, a slide containing periodic table information, a slide containing physical and chemical properties of the element, a slide containing information on the discovery of the element, a slide containing information about the location of the element and how it is obtained, a slide containing uses of the element, and a works cited slide.

(Note: The response below provides an example of the scientific content that should be contained within this project and does not contain general content, such as the title slide and works cited.)

Multimedia Presentation about Gold

Periodic Table Information
Gold (Au)
- Type of Element: Metal
- Atomic Number: 79
- Atomic Mass: 196.67
- 79 Protons; 118 Neutrons; 79 electrons
- Period 6, Group 11- Coinage metals
Physical and Chemical Properties

- Bright yellow color
- Solid at room temperature
- Shiny, soft, and generally smooth
- Odorless
- Malleable and ductile
- Melting point: 1064 degrees Celsius
- Boiling point: 2807 degrees Celsius
- Not very reactive, nor flammable

The Discovery of Gold as an Element

- 1948
- California
- James W. Marshall

Location of Gold and How it is Obtained

- Gold is found all over the world.
- There is a lot of gold in the oceans.
- Panning method
- Extraction
Uses of Gold

- Coins
- Jewelry
- Electronics
- Teeth fillings
- Space equipment
- Gold mining can cause contaminated water
Argumentative Writing Student Sample

This student exemplar serves to provide teacher guidance regarding the project response that students will write in the lesson Renewable Resources.

Assignment summary: For this assignment, you will conduct research and evaluate how various roads that have been built in rainforests impact people and the Earth. Based on your research and evaluation, you will write a position paper expressing whether you are for or against the building of roads in rainforests. Then you will share and discuss with your classmates your position.

Roads in a Rainforest

Roads are being built in rainforests like the Amazon for many reasons. Some are used for connecting small towns or rural areas. Roads are also useful to businesses transporting products in and out of the areas around rainforests. These roads have several environmental effects since they require removing lots of trees in the process. This deforestation is taking a toll on rainforests because thousands of miles of roads are being constructed each year. The loss of so many trees is greatly damaging the rainforest ecosystem. Tourism is also damaging the rainforests, as tourists’ needs lead to the construction of more roads, hotels, and resorts.

Roads in the rainforest should be constructed only sparingly. Road-building is a cause of deforestation, which has many negative effects. One effect is loss of habitat. A single tree is home to many organisms and when it is cut down for a road, the species loses a place to live. This is just one impact deforestation has on the rainforest ecosystem. Another effect of deforestation is seen in the atmosphere. Trees take in carbon dioxide and release oxygen into the air. When trees are cut down, less carbon dioxide is taken in. An increase in carbon dioxide, a greenhouse gas, can lead to changes in climate all over the world. Even if you do not live near a rainforest, deforestation from road construction can impact you. Some people think that the roads should still be built because they are important for local communities and businesses. A solution to this would be to build a few roads strategically. This way you have some important roads available but you are only causing limited deforestation.
RUBRICS
Edgenuity courses contain rubrics for educators to aid in scoring of specific student activities. Teachers will find the rubrics by clicking on the assignment for the lab or project.

Students are able to access rubrics when working on an assignment to evaluate their work, or that of a peer, prior to submission.
### Narrative/Procedural Writing Rubric

#### High School Descriptive Lab Report Rubric

| Purpose and Procedure | Data and Analysis | Conclusions | Organization | Mechanics and Conventions 
|------------------------|------------------|-------------|--------------|-----------------------------
| The extent to which the report demonstrates a clear, organized structure and purpose using a coherent list of procedural steps | The extent to which the report demonstrates a clear, organized structure and purpose using a coherent list of data analysis | The extent to which the report demonstrates a well thought-out analysis and conclusion | The extent to which the report follows the lab report guidelines | The extent to which the report demonstrates control of mechanics, including grammar, punctuation, and spelling |
| **Weight** | 20% | 30% | 20% | 10% | 10% |

**6: Very Precise**
- The purpose of the lab is clearly identified and stated. Procedures are listed in logical order, but steps are not numbered or are not written in complete sentences.
- Variables are all included in the analysis. The trends and patterns in the data are logically analyzed.
- Conclusions are logical and supported by the data. The conclusions are supported by the results of the lab. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.
- The lab report follows all the lab report guidelines, but is missing one of the following elements: includes all major elements of a lab report, includes all major elements of a lab report, omits the teacher’s content and format expectations, omits the teacher’s content and format expectations. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.

**5: Precise**
- The purpose of the lab is clearly identified and stated. Procedures are listed in logical order, but steps are not numbered or are not written in complete sentences.
- Variables are all included in the analysis. The trends and patterns in the data are logically analyzed.
- Conclusions are logical and supported by the data. The conclusions are supported by the results of the lab. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.
- The lab report follows most of the lab report guidelines. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.

**4: Adequate**
- The purpose of the lab is identified, but it is stated in a somewhat unclear manner: procedures are listed in logical order, but steps are not numbered or are not written in complete sentences.
- Variables are all included in the analysis. The trends and patterns in the data are logically analyzed.
- Conclusions are logical and supported by the data. The conclusions are supported by the results of the lab. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.
- The lab report follows many of the lab report guidelines. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.

**3: Limited**
- The purpose of the lab is identified, but it is stated in a somewhat unclear manner: procedures are listed in logical order, but steps are not numbered or are not written in complete sentences.
- Variables are all included in the analysis. The trends and patterns in the data are logically analyzed.
- Conclusions are logical and supported by the data. The conclusions are supported by the results of the lab. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.
- The lab report follows some of the lab report guidelines. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.

**2: Inadequate**
- The purpose of the lab is unclear or missing. The analysis is missing from the lab report.
- Variables are not all included in the analysis. The trends and patterns in the data are logically analyzed.
- Conclusions are logical and supported by the data. The conclusions are supported by the results of the lab. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.
- The lab report contains some of the major elements of a lab report. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.

**1: Inadequate**
- The purpose of the lab is unclear or missing. The analysis is missing from the lab report.
- Variables are not all included in the analysis. The trends and patterns in the data are logically analyzed.
- Conclusions are logical and supported by the data. The conclusions are supported by the results of the lab. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.
- The lab report contains no major elements of a lab report. There is no evidence of bias or error, and what was learned from the investigation. Predictions are made about what might happen if part of the lab were to be changed.
## Expository/Informative Writing Rubric

<table>
<thead>
<tr>
<th>Idea and Presentation Rubric</th>
<th>Organization</th>
<th>Multimedia Elements</th>
<th>Tone and Voice</th>
<th>Conventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>The overall development, accuracy, and effectiveness of the presentation</td>
<td>Appropriate structure and overall organization</td>
<td>Engaging and effective use of multimedia to support the presentation</td>
<td>The effectiveness of the language used in the presentation and the unique perspective of the writer</td>
<td>Mechanical and grammatical accuracy that is appropriate to the task, purpose, and audience</td>
</tr>
</tbody>
</table>

### Weight

- 20%
- 20%
- 20%
- 20%
- 20%

### Ideas and Presentation Rubric

#### Exceptional
- The presentation clearly ties out the problem and its effect.
- It provides a simple solution using evidence.

#### Outstanding
- The presentation is clearly structured. The relationship between the problem, its effects, and the student’s solution is clear.

#### Proficient
- The presentation is clearly structured. The relationship between the problem, its effects, and the student’s solution is clear.

#### Developing
- The presentation is clearly structured. The relationship between the problem, its effects, and the student’s solution is clear.

#### Beginning
- The presentation does not discuss a problem and solution, but it lacks meaningful organization.

### Organization

#### Exceptional
- The presentation clearly ties out the problem and its effect.
- It provides a simple solution using evidence.

#### Outstanding
- The relationship between the problem, its effects, and the student’s solution is clear.

#### Proficient
- The relationship between the problem, its effects, and the student’s solution is clear.

#### Developing
- The relationship between the problem, its effects, and the student’s solution is clear.

#### Beginning
- The presentation does not discuss a problem and solution, and there is no meaningful organization.

### Multimedia Elements

#### Exceptional
- Multimedia elements are supportive and highly effective, aiding the student’s understanding.
- The connection to the topic is clear and compelling.

#### Outstanding
- Multimedia elements are supportive and highly effective, aiding the student’s understanding.
- The connection to the topic is clear and compelling.

#### Proficient
- Multimedia elements contribute to the presentation. The connection to the topic is clear.

#### Developing
- Multimedia elements occasionally contribute to the presentation. The connection to the topic may be unclear or inconsistent.

#### Beginning
- Multimedia elements are used to poor effect, making the presentation unclear or difficult to understand.

### Tone and Voice

#### Exceptional
- Test and graphics show clear understanding, clearly communicating the connection to the subject and purpose.

#### Outstanding
- Test and graphics show clear understanding, clearly communicating the connection to the subject and purpose.

#### Proficient
- Test and graphics show clear understanding, clearly communicating the connection to the subject and purpose.

#### Developing
- Test and graphics occasionally show understanding, the connection to the subject and purpose is largely appropriate.

#### Beginning
- Test and graphics show little or no understanding, the connection to the subject and purpose is inappropriate.

### Conventions

#### Exceptional
- There are few or no errors in grammar, mechanics, punctuation, and spelling. The errors do not affect the presentation significantly.

#### Outstanding
- There are some errors in grammar, mechanics, punctuation, and spelling, but the errors do not affect the presentation significantly.

#### Proficient
- There are some errors in grammar, mechanics, punctuation, and spelling, but the errors do not affect the presentation significantly.

#### Developing
- There are numerous errors in grammar, mechanics, punctuation, and spelling, which significantly affect the presentation.

#### Beginning
- There are numerous errors in grammar, mechanics, punctuation, and spelling, which significantly affect the presentation.

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## Argumentative Writing Rubric

<table>
<thead>
<tr>
<th>As you review the student's work, make sure that the graphic organizer, position paper, and discussion evaluation accomplish all of the following.</th>
<th>Points Possible</th>
<th>Points Earned</th>
</tr>
</thead>
<tbody>
<tr>
<td>The graphic organizer is complete, including an explanation of how building a road through the rainforest would affect the stakeholder and whether the effects would be positive, negative, or both.</td>
<td>30.0</td>
<td></td>
</tr>
<tr>
<td>The paper explains the issue of building roads in the rainforest and provides background information about the importance of resources in the rainforest.</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>The paper states the student's position for or against building the roads.</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>The paper provides fact-based supporting evidence for the student's position.</td>
<td>10.0</td>
<td></td>
</tr>
<tr>
<td>The paper gives at least one counterevidence to the student's position.</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>The paper includes proper spelling, punctuation, capitalization, and grammar.</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>The student completed the class discussion evaluation with thoughtful responses, free of spelling and grammatical errors.</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>160.0</td>
<td></td>
</tr>
</tbody>
</table>
## Multimedia Presentation Rubric

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Content</th>
<th>Organization</th>
<th>Language and Conventions</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>The extent to which all required components are met or exceeded.</td>
<td>The extent to which the topic is addressed using specific, accurate, and relevant details.</td>
<td>The extent to which the presentation demonstrates structure and flow.</td>
<td>The extent to which wording is appropriately chosen, and grammar, punctuation, and spelling are correctly implemented.</td>
<td>The extent to which sources are appropriately chosen and properly cited.</td>
</tr>
<tr>
<td>Weight (%)</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Very Effective</td>
<td>Covers the topic in-depth with meaningful examples. Subject knowledge is excellent.</td>
<td>Demonstrates a well-organized structure and flow. Consistently uses headings or bulleted lists to group related material.</td>
<td>Demonstrates proper word choice. Few errors in grammar, punctuation, and spelling.</td>
<td>All source information for facts and graphics is collected and properly cited.</td>
</tr>
<tr>
<td>Good</td>
<td>Includes essential information about the topic, with details and examples when needed. Subject knowledge appears to be good.</td>
<td>Demonstrates an organized structure and flow. Often uses headings or bulleted lists to group related material.</td>
<td>Demonstrates good word choice. Few errors in grammar, punctuation, and spelling that do not significantly interfere with communication of content.</td>
<td>All source information for facts and graphics is collected, but some of the information is not properly cited.</td>
</tr>
<tr>
<td>Adequate</td>
<td>All requirements are met, but not fully addressed.</td>
<td>Demonstrates some structure and flow. Content is somewhat disorganized with moderate use of headings or bulleted lists to group related material.</td>
<td>Demonstrates adequate word choice. Some errors in grammar, punctuation, and spelling that do not significantly interfere with communication of content.</td>
<td>Most source information for facts and graphics is collected, but some of the information is not properly cited.</td>
</tr>
<tr>
<td>Limited</td>
<td>Some information about the topic is missing and there are 1–2 content errors.</td>
<td>Demonstrates some evidence of structure with uncertain content flow. Demonstrates limited use of headings or bulleted lists to group related material.</td>
<td>Demonstrates simple word choice. Several errors in grammar, punctuation, and spelling that may interfere with communication of content.</td>
<td>Most source information for facts and graphics is collected, but much of the information is not properly cited.</td>
</tr>
<tr>
<td>Minimal</td>
<td>Very little source information for facts and graphics was collected and cited.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Rubric (continued)

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two requirements were not met.</td>
<td>Information about the topic is minimal and there are several content errors.</td>
</tr>
<tr>
<td>Minimal</td>
<td>Demonstrates little evidence of structure with poor content flow. Demonstrates little evidence of headings or bulleted lists to group related material.</td>
</tr>
<tr>
<td>Minimal</td>
<td>Demonstrates simple word choice. Many errors in grammar, punctuation, and spelling that interfere with communication of content.</td>
</tr>
<tr>
<td>Minimal</td>
<td>Very little source information for facts and graphics was collected and cited.</td>
</tr>
<tr>
<td>Inadequate</td>
<td>Three or more requirements were not met.</td>
</tr>
<tr>
<td>Inadequate</td>
<td>Information about the topic is incomplete and inadequate, and not sufficiently supported by details. There are 2 or more content errors.</td>
</tr>
<tr>
<td>Inadequate</td>
<td>Demonstrates no evidence of structure or flow. There is no use of headings or bulleted lists, just a number of facts.</td>
</tr>
<tr>
<td>Inadequate</td>
<td>Demonstrates poor word choice. Severe errors in grammar, punctuation, and spelling that significantly interfere with communication of content.</td>
</tr>
<tr>
<td>Inadequate</td>
<td>No source information for facts and graphics was collected or cited.</td>
</tr>
</tbody>
</table>
VOCABULARY

Each lesson introduces scientific vocabulary and integrates these vocabulary words into instruction and assignments so that students understand word meaning in context. The following lesson examples show how vocabulary is selected and how terms are scaffolded for different proficiency levels.

UNIT 1: ATOMS AND THE PERIODIC TABLE

Lesson 1: Atomic Theory

On-level Words

- atom: smallest possible particle of an element
- chemical: any substance that has a specific element or combination of atoms
- compound: a pure substance that is made up of atoms of two or more elements
- charge: having positive or negative electrical energy
- electric: associated with the energy from the flow of electrons
- neutral: an overall charge of zero due to an equal amount of positive and negative charges
- proportion: a comparison or relationship between two values

Supporting Words

- predict: to guess based on evidence such as a mathematical equation or model
- specific: exact or having a certain measured value

Advanced Words

- emission: discharge or release
- energy levels: orbitals that electrons may occupy around the nucleus of an atom that are associated with a specific amount of energy

Lesson 2: Atoms

On-level Words

- atomic mass unit: a standard unit of mass used for subatomic particles
- electron: a negatively charged particle that orbits the nucleus of an atom
- electron cloud: the area of the atom surrounding the nucleus where electrons can be found
- neutron: a neutral particle located in the nucleus of an atom
- nucleus: the central part of the atom containing protons and neutrons
- particle: a very small part or piece of something
- proton: a positively charged particle located in the nucleus of an atom
Supporting Words
- identify: to determine what something is

Advanced Words
- subatomic: part of an atom

Lesson 3: Elements

On-level Words
- atomic number: the number of protons in the nucleus of an atom
- compound: a substance that is made up of two or more elements
- element: a substance that is made up of only one type of atom
- ion: an atom with a positive or negative charge due to the loss or addition of one or more electrons
- isotope: an atom that has the same number of protons but a different number of neutrons than other atoms of the same element
- mass number: the total number of protons and neutrons in the nucleus of an atom
- valence electrons: electrons found in the outermost energy level of an atom that are used in bonding

Supporting Words
- balance: stability between opposing traits
- property: a quality belonging to all members of a group

Advanced Words
- isolate: to set apart

Lesson 4: Periodic Table

On-level Words
- atomic mass: the average mass of all isotopes of an element
- group: a vertical column of elements in the periodic table
- period: a horizontal row of elements in the periodic table
- periodic table: a table that organizes the chemical elements in order of increasing atomic number and that groups elements based on similarities in chemical properties and electron configurations
Supporting Words

- classify: arrange in classes or groups
- category: a distinct class where all included concepts belong

Advanced Words

- relative: considered in relation or in proportion to something else

Lesson 5: Metals

On-level Words

- ductile: able to be stretched into long thin shapes without breaking
- electrical conductivity: a measure of how well a substance allows electric current to flow through it
- malleable: able to be shaped (as with a mallet) without breaking
- metal: an element that is lustrous, solid at room temperature, malleable and ductile, conducts heat and electricity, and forms basic compounds
- opaque: does not allow light to pass through; unable to be seen through
- thermal conductivity: a measure of how well a substance allows heat to pass through it

Supporting Words

- periodic: repeating at regular intervals

Advanced Words

- lustrous: having a shiny appearance

Lesson 6: Nonmetals

On-level Words

- electrical insulator: a substance that does not allow electric current to flow easily
- halide: a chemical compound formed with at least one halogen element from group 17
- halogen: any of the highly reactive elements in group 17 of the periodic table
- noble gas: any of the stable, mostly nonreactive elements in group 18 of the periodic table
- nonmetal: an element that is usually gaseous at room temperature, is brittle, an insulator of heat and electricity, and forms acidic compounds
- thermal insulator: a substance that does not allow heat to pass easily
- volatile: evaporates easily
Supporting Words

- bond: a uniting force

Advanced Words

- brittle: shatters or breaks easily
- density: the mass of a substance per volume

Lesson 7: Metalloids

On-level Words

- amphoteric: a substance that can form acidic or basic compounds
- glass: material formed by the melting and cooling of silica
- metalloid: an element which is lustrous, solid at room temperature, brittle, a semiconductor of heat and electricity, and forms both acidic and basic compounds
- semiconductor: a substance that has intermediate electrical conductivity

Supporting Words

- behavior: the way in which an element acts

Advanced Words

- solid state: the behavior of atoms and subatomic particles in a solid substance
- vacuum tube: an electron tube empty of almost all matter
UNIT 2: STATES AND PROPERTIES OF MATTER

Lesson 1: Introduction to Matter

On-level Words

- atom: the smallest unit of matter
- displacement: the movement of something from its original position
- mass: the amount of matter in an object
- matter: the stuff that everything is made of
- volume: the amount of space an object takes up
- weight: the downward pull on an object due to gravity

Supporting Words

- balance: a tool used to measure mass
- scale: a tool used to measure weight

Advanced Words

- data: factual information
- hypothesis: well-educated guess

Lesson 2: States of Matter

On-level Words

- crystalline solid: a solid whose atoms are arranged in a repeating pattern
- gas: a substance that does not retain either volume or shape due to atoms that spread out
- liquid: a substance that retains its volume, but not shape, due to packed atoms that can slide past one another
- noncrystalline solid: a solid whose atoms lack a particular pattern
- solid: a substance that retains its shape and volume due to closely packed atoms
- surface tension: the result of water molecules pulling inwards with a strong attractive force
- viscosity: a liquid’s resistance to flow

Supporting Words

- definite: unchanging; not likely to change
- shape: a definite form

Advanced Words

- attractive force: a force that can draw a substance toward it
- vibrate: to quickly move back and forth
Lesson 3: Changes of State

On-level Words

- boiling: vaporization that occurs below the surface of a liquid and produces bubbles
- condensation: the process by which a gas becomes a liquid
- deposition: the process by which a gas becomes a solid
- evaporation: vaporization that occurs at the surface of a liquid
- freezing: the process by which a liquid becomes a solid
- kinetic energy: the energy resulting from the motion of particles
- melting: the process by which a solid becomes a liquid
- physical change: a change in one or more physical properties of a substance but not its identity
- sublimation: the process by which a solid becomes a gas
- vaporization: a process by which a liquid becomes a gas

Supporting Words

- temperature: a measure of the average kinetic energy of the particles in a substance

Advanced Words

- air pressure: pushing on a surface due to the weight of air particles

Lesson 4: Physical Properties

On-level Words

- boiling point: the temperature at which a liquid becomes a gas
- buoyant force: the upward force on an object in a fluid
- conductivity: the ability of a substance to transfer heat or electricity
- density: the amount of mass in a given volume
- melting point: the temperature and pressure at which a solid becomes a liquid
- physical change: a change in some of the physical properties of matter but not in its identity
- physical property: a characteristic of a substance that can be observed and that does not change the identity of the substance
- solubility: the ability of one substance to dissolve in another

Supporting Words

- energy: the ability of matter to change and move

Advanced Words

- conserve: specific quality of a substance remains the same from beginning to end
- magnetism: the ability of a substance to attract certain metals
Lesson 5: Density

On-level Words

- density: the amount of mass in a given volume
- derived: obtained from something else
- mass: the amount of matter in an object
- relative: compared to something else
- volume: the amount of space an object takes up

Supporting Words

- float: density is less than the density of the surrounding liquid
- sink: density is greater than the density of the surrounding liquid

Advanced Words

- constant: remaining unchanged

Lesson 6: Lab: Density of Solids

On-level Words

- buoyancy: a characteristic of an object determined by how it sinks or floats in a fluid
- density: the amount of mass in a given volume
- fluid displacement: a method to determine the volume of an object by submerging it in a liquid and observing the apparent increase in the liquid volume
- irregularly shaped: having an intricate shape or dimensions that are not easily measured
- regularly shaped: having a regular geometric shape or easily measured dimensions

Supporting Words

- estimate: approximate a value
- proportional: a comparison or relationship between two values

Advanced Words

- submerge: to put underwater
Lesson 7: Chemical Properties

On-level Words

- chemical change: a change in matter that results in a change in its identity and properties
- chemical property: a characteristic of matter that describes its ability to change into a different substance
- combustibility: the ability of a substance to burn
- reactivity: the ability of a substance to combine chemically with another

Supporting Words

- identity: what a substance is, including its properties and characteristics, based on its chemical structure

Advanced Words

- indicator: something that shows a change has occurred
- reversibility: the capability of something to return to its former state
UNIT 3: CHEMICAL BONDING AND COMPOUNDS

Lesson 1: Chemical Bonding

On-level Words

- chemical bond: a force that holds atoms together
- covalent bond: bond where atoms share electrons
- electron dot diagram: a model of an atom showing the electrons in its valence shell
- force: a push or pull on an object
- ionic bond: bond where one atom transfers one or more electrons to another atom
- metallic bond: bond where many atoms share many electrons
- octet rule: the rule that an atom needs eight valence electrons in its shell to become stable; the exceptions are hydrogen and helium, which need two electrons
- valence electrons: the electrons in the outermost shell of an atom
- valence shell: the outermost shell of an atom

Supporting Words

- atom: the smallest part of matter that cannot be separated into smaller parts by ordinary means
- stable: firmly established and unlikely to change

Advanced Words

- correlation: a connection or relationship between two or more concepts

Lesson 2: Compounds

On-level Words

- chemical formula: a representation of a compound; gives the number of atoms and types of atoms in a compound
- coefficient: a number that indicates how many times to multiply a variable
- compound: a pure substance that is made up of atoms of two or more different elements
- differentiate: to contrast or to show how two or more things are different from one another
- molecule: a unit of two or more atoms
- subscript: a letter, number, or symbol that is smaller and just below normal line of type

Supporting Words

- element: a substance that is made up of only one type of atom
- model: a representation of an idea or a thing
Advanced Words

- chemical formula: provides the total number of atoms for each element in a molecule
- diatomic molecule: combination of elements consisting of only one element

Lesson 3: Ionic Bonds

On-level Words

- crystal: a smooth solid formed by repeating patterns of ions, atoms, or molecules
- electrical force: a force between two charged ions, objects, or particles
- ionic bond: a chemical bond formed between a metal and a nonmetal that involves the transfer of electrons and attraction between ions
- ionic compound: a compound whose atoms form bonds by transferring electrons
- polyatomic ion: an ion made of two or more atoms of different elements
- property: a characteristic of something

Supporting Words

- brittle: describes something that can break easily
- charge: having positive or negative electrical energy

Advanced Words

- crystal lattice: pattern that ions are arranged in a crystal
- dissolve: the ability to mix with and become part of a liquid

Lesson 4: Covalent Bonds

On-level Words

- brittle: describes something that can break easily
- covalent bond: a chemical bond formed between nonmetals that involves the sharing of electrons
- covalent compound: a compound whose atoms form bonds by sharing electrons
- double bonds: two atoms share four electrons
- property: a characteristic of something
- single bond: two atoms share two electrons
- triple bonds: two atoms share six electrons

Supporting Words

- share: to give or receive
Advanced Words

- ultraviolet ray: a part of sunlight consisting of harmful radiation

Lesson 5: Lab: Ionic and Covalent Bonds

On-level Words

- conductivity apparatus: an apparatus that measures the movement of ions in a sample or solution
- covalent bond: a chemical bond formed between nonmetals that involves the sharing of electrons
- crystal: a smooth solid formed by repeating patterns of ions, atoms, or molecules
- electrical conductivity: allows the easy flow of an electric current
- ionic bond: a chemical bond formed between a metal and a nonmetal that involves the transfer of electrons and attraction between ions
- solubility: the ability of one substance to dissolve in another

Supporting Words

- appearance: the way something looks
- texture: the structure or feel of something

Advanced Words

- cross-contamination: when a substance from an earlier test is still present in a later test due to improper cleaning
- distilled: purified

Lesson 6: Naming Ionic Compounds

On-level Words

- charge: having positive or negative electrical energy
- chemical formula: a representation of a compound; gives the number of atoms and types of atoms in a compound
- chemical symbol: a representation of an element
- ion: an atom with a positive or negative charge due to the loss or addition of one or more electrons
- IUPAC: an acronym for International Union of Pure and Applied Chemistry; an international scientific organization that contributes to the development of chemistry and the use of chemistry to benefit society
- nomenclature: a system of naming based on a set of rules
- subscript: a letter, number, or symbol that is smaller and just below the normal line of type
- superscript: a letter, number, or symbol that is smaller and just above the normal line of type
Supporting Words

- balance: when opposing forces have become equal to one another
- represent: to be used in place of something else

Advanced Words

- suffix: a letter or group of letters with its own meaning that comes at the end of a word

Lesson 7: Naming Covalent Compounds

On-level Words

- chemical formula: a representation of a compound; gives the number of atoms and types of atoms in a compound
- chemical symbol: a representation of an element
- common name: a name that does not follow IUPAC nomenclature but is used to identify a compound
- IUPAC: an acronym for International Union of Pure and Applied Chemistry; an international scientific organization that contributes to the development of chemistry and the use of chemistry to benefit society
- nomenclature: a system of naming based on a set of rules
- subscript: a letter, number, or symbol that is smaller and just below normal line of type

Supporting Words

- represent: to be used in place of something else

Advanced Words

- prefix: a letter or group of letters with its own meaning that comes at the beginning of a word
- suffix: a letter or group of letters with its own meaning that comes at the end of a word

Lesson 8: Metallic Bonds

On-level Words

- alloy: a mixture of the atoms of a metal with another element
- ductility: the ability of metals to be formed into wires
- electrical conductivity: allows the flow of an electric current
- electron sea theory: a theory that states that metals bond to other metals by sharing many “floating” electrons
- malleability: the ability of metals to be shaped by hammering or pounding
- metallic bond: the chemical bond formed when metal atoms share many mobile electrons
- thermal conductivity: allows the flow of heat
Lesson 9: Polymers

Supporting Words
- shininess: the ability to reflect light off moving electrons

Advanced Words
- brass: an alloy of copper and zinc
- bronze: an alloy of copper and tin

On-level Words
- biodegradable: having the ability to be broken down by bacteria and other natural ways
- landfill: a place where trash is brought to be buried underground
- macromolecule: a very large molecule
- monomer: a simple molecule that can bond with other simple molecules to form a polymer
- natural polymer: a polymer that exists in nature and is made by living organisms
- polymer: a macromolecule that is made of many monomers
- polymerization: the process by which monomers combine in long strands to form polymers
- subunit: a part of a larger whole
- synthetic polymer: a polymer that is human-made

Supporting Words
- flexible: the ability to bend
- resistant: the ability to oppose a force

Advanced Words
- DNA: natural polymer found in all living things that passes genetic information from parent to offspring
- polyethylene: synthetic polymer used to make plastic items
UNIT 4: CHEMICAL REACTIONS

Lesson 1: Introduction to Chemical Reactions

On-level Words

- absorb: to receive or take in
- chemical reaction: the rearrangement of atoms by the breaking and reforming of chemical bonds
- endothermic: a reaction that absorbs heat from the surroundings
- exothermic: a reaction that releases heat to the surroundings
- indicator: something that shows a change has occurred
- precipitate: a solid that forms when two liquids react

Supporting Words

- rearrange: to come together in a different way

Advanced Words

- radiate: to spread out from a central point

Lesson 2: Describing Chemical Reactions

On-level Words

- chemical equation: a shorthand that uses chemical symbols and molecular formulas to show what occurs during a chemical reaction
- coefficient: a number that indicates how many times to multiply a variable
- law of conservation of mass: a natural law stating that the same amount of mass is present before and after a chemical reaction
- products: the chemicals present after a chemical reaction occurs
- reactants: the chemicals present before a chemical reaction occurs
- subscript: a letter, number, or symbol that is smaller and just below the normal line of type

Supporting Words

- reversible: when something can return to its former state
- react: to behave in response to an action

Advanced Words

- electrolysis: a method used to break the bonds between hydrogen and oxygen atoms in water
Lesson 3: Balancing Chemical Equations

On-level Words

- ammonia: a chemical used in cleaning products; made up of one nitrogen atom and three hydrogen atoms
- coefficient: a number that indicates how many times to multiply a variable
- law of conservation of mass: natural law that states the same amount of mass is present before and after a chemical reaction
- products: the chemicals present after a chemical reaction occurs
- reactants: the chemicals present before a chemical reaction occurs
- system: a group of related objects that interact and form a complex whole
- subscript: a letter, number, or symbol that is smaller and just below the normal line of type

Supporting Words

- balance: the state of being in equal amounts

Advanced Words

- common denominator: a number that is a multiple of both numbers in a set

Lesson 4: Types of Chemical Reactions

On-level Words

- combustion: a type of chemical reaction that involves the combination of oxygen and fuel
- decomposition: a type of chemical reaction that involves one chemical compound that breaks into two or more separate compounds or elements
- hydrocarbon: a compound containing only hydrogen and carbon
- oxidation: the addition of oxygen to a chemical substance
- polymerization: the process by which monomers combine in long strands to form polymers
- replacement: a type of chemical reaction that involves the exchange of ions in ionic compounds
- synthesis: a type of chemical reaction that involves the combination of substances to create a product that is a chemically bonded combination of the reactants

Supporting Words

- classify: to assign to groups or classes
- solution: when matter is dissolved in a liquid

Advanced Words

- outgassing: releasing of a gas or vapor
Lesson 5: Rate of Chemical Reactions

On-level Words

- activation energy: the minimum amount of energy needed to start a chemical reaction
- catalyst: a substance that lowers the activation energy needed to start a chemical reaction
- concentration: the amount of one substance in a certain volume of another substance
- inhibitor: a substance that slows down or stops a chemical reaction
- kinetic energy: the energy an object has due to its motion
- particle motion: the motion of atoms and molecules in a substance
- pressure: the extra weight on an object from pushing or pressing against it
- surface area: the total area of the exposed surface of an object
- temperature: a measure of the average kinetic energy of the particles in a substance

Supporting Words

- collision: the act of two substances forcibly coming together

Advanced Words

- preservative: an inhibitor that is used to keep food from spoiling

Lesson 6: Lab: Rate of Chemical Reactions

On-level Words

- catalyst: a substance that lowers the activation energy needed to start a chemical reaction
- concentration: the amount of one substance in a certain volume of another substance
- effervescent: the appearance of bubbles due to escaping gas
- reaction rate: the speed at which a chemical reaction takes place
- surface area: the amount of area covered by the outside surface of an object
- temperature: a measure of the average kinetic energy of the particles in a substance

Supporting Words

- dissolve: the ability to mix with and become part of a liquid
- tablet: a flat solid slab

Advanced Words

- antacid: a substance that neutralizes acids
UNIT 5: MIXTURES, SOLUTIONS, AND ACID-BASE REACTIONS

Lesson 1: Mixtures

On-level Words

- colloid: a heterogeneous mixture in which small particles of one substance are dispersed evenly throughout another substance
- dispersed: spread evenly throughout another material
- dispersion medium: the substance in a colloid in which the particles of the other substance are dispersed
- heterogeneous: a substance in which the mixed substances are distinguishable from one another
- homogeneous: a substance that has the same appearance and properties throughout
- mixture: a combination of two or more pure substances
- pure substance: a substance whose characteristics and chemical composition do not change from sample to sample
- solute: the substance in a solution that gets broken down
- solution: a homogeneous mixture in which the molecules of one substance break down and completely surround the molecules of another substance
- solvent: the substance in a solution that surrounds and breaks down the solute
- suspension: a heterogeneous mixture in which solid dispersed particles are larger and will eventually settle

Supporting Words

- alloy: a mixture of the atoms of a metal with another element

Advanced Words

- tarnish: to dull the natural shine of a substance

Lesson 2: Separation of Mixtures

On-level Words

- centrifuge: a device that separates mixtures in tubes by spinning them at a high speed so that the acceleration causes denser substances to settle toward the outside of the tube
- decant: to pour off the top layer
- distillation: a method of separating mixtures in which the mixture is heated until just one substance evaporates, and the pure vapor is collected and condensed
- evaporation: the process of a liquid becoming a gas from a liquid
• filtration: passing a mixture through a layer of sharp-edged particles, such as sand, so that all particles in the mixture of a certain size and consistency will be caught in the filter and separated from the mixture
• magnetic separation: using a magnet to separate magnetic particles from a mixture
• ore: any mixture of minerals that forms naturally within Earth’s crust
• screening: passing a mixture through a screen so that all particles above a certain size are caught and separated from the mixture

Supporting Words
• pellet: a usually small rounded object

Advanced Words
• emulsion: another term for colloid, or a heterogeneous mixture in which small particles of one substance are dispersed evenly throughout another substance

Lesson 3: Solubility

On-level Words
• concentration: the amount of one substance in a certain volume of another substance
• dilute: weak solution that has a small amount of solute compared to the solvent, usually by adding water
• saturated solution: a solution with as much dissolved solute as the solution can hold at a given temperature
• solubility: the ability of one substance to dissolve in another
• supersaturated solution: a heated solution with more dissolved solute than the solution can hold at a lower temperature
• unsaturated solution: a solution that holds less dissolved solute than is possible at a given temperature

Supporting Words
• dissolve: the ability to mix with and become part of a liquid
• level: the amount of a substance in relation to a value

Advanced Words
• dictate: to state with authority
• temporarily: a limited period of time
Lesson 4: Properties of Acids and Bases

On-level Words
- acid: a substance that tastes sour and reacts with metals and carbonates
- base: a substance with a bitter taste and slippery texture that reacts with lipids
- carbonate: a chemical made up of molecules that contain a CO3 ion
- hydroxide: a negatively charged ion formed from one atom of hydrogen and one atom of oxygen
- lipids: naturally occurring, fatty compounds that make up substances such as oil, grease, and wax

Supporting Words
- soap: the substance produced when a base mixes with oil, grease, or wax, which can then be used to break down other fats

Advanced Words
- limestone: a rock composed of calcium carbonate that can form caves

Lesson 5: Acids and Bases in Solution

On-level Words
- neutralization: a reaction between an acid and a base to form water and a salt
- pH: a value used to describe how acidic or basic a solution is
- salt: an ionic compound formed when an acid reacts with a base
- spectator ions: ions that do not change after a neutralization reaction occurs
- strong acid or base: breaks down completely in water
- weak acid or base: does not break down completely in water

Supporting Words
- cabbage juice: an indicator that changes color depending on the acidity or basicity of the solution
- indicator: something that shows a change has occurred

Advanced Words
- litmus paper: an indicator that turns red in the presence of an acid (if originally blue) and blue in the presence of a base (if originally red)
- spectator ions: ions that do not change after a neutralization reaction occurs
Lesson 6: Lab: Acids and Bases

On-level Words

- acid: a substance that releases H+ ions in solution
- base: a substance that releases OH- ions in solution
- H+ ion: a positively charged ion composed of one hydrogen atom
- OH- ion: a negatively charged ion composed of one oxygen atom and one hydrogen atom
- pH: a scale for measuring the acidic or basic properties of a solution

Supporting Words

- approximate: take an educated guess at

Advanced Words

- logarithmic: a type of scale where what is being measured changes on a scale of $10^x$
- exponential: expressed by a mathematical exponent, where a number is raised to a power
UNIT 6: MOTION AND FORCES

Lesson 1: Introduction to Motion

On-level Words

• compare: the careful observation of two or more things to identify similarities and/or differences between them
• displacement: the change in position from a reference point
• quantity: the amount or measure of something
• reference point: the location or object used for comparison to determine another location
• standard unit: an agreed-upon consistent amount as a unit of measurement

Supporting Words

• direction: the course that something is moving or facing
• distance: how far an object travels

Advanced Words

• metric: a standard of measurement expressed in base ten units

Lesson 2: Speed and Velocity

On-level Words

• average: the sum of all items in a data set divided by the total number of items
• instantaneous: occurring immediately
• position vs. time graph: a graph that shows the relationship between the position of an object over time; time is plotted on the x-axis, and the position of the object is plotted on the y-axis
• slope: the steepness of a line on a graph; abbreviated by m and calculated by \( m = (y_2 - y_1)/(x_2 - x_1) \)
• speed: the distance traveled per unit of time
• velocity: a displacement per unit of time; or distance traveled per unit of time in a specific direction

Supporting Words

• versus: against, in comparison with something else
• vs.: abbreviation for versus

Advanced Words

• coordinate: one of a set of numbers used to locate a point on a line or graph
• speedometer: instrument in a vehicle that shows instantaneous speed
Lesson 3: Acceleration

On-level Words

- acceleration: the rate of change of velocity
- negative acceleration: a type of acceleration that describes the slowing down of an object
- positive acceleration: a type of acceleration that describes the speeding up of an object
- velocity vs. time graph: a graph that shows the relationship between the velocity of an object over time; time is plotted on the x-axis, and the velocity of the object is plotted on the y-axis

Supporting Words

- initial: at the beginning
- final: at the end

Advanced Words

- delta: change in, designated by a triangle sign

Lesson 4: Lab: Motion

On-level Words

- acceleration: the rate of change of velocity; velocity per unit of time
- motion: when an object changes position from a reference point
- speed: the distance traveled per unit of time
- velocity: a displacement per unit of time; distance traveled per unit of time in a specific direction

Supporting Words

- slope: the steepness of a line on a graph; abbreviated by m and calculated by \( m = (y_2 - y_1)/(x_2 - x_1) \)

Advanced Words

- quantitative: expressed in terms of quantity

Lesson 5: Introduction to Forces

On-level Words

- balanced force: when forces acting in opposite directions are equal
- contact force: a force that occurs due to interaction of objects
- counteract: to act against something, causing it to have less of an effect
- force: a push or pull
- force diagram: shows what forces are acting on an object
- friction: a resistance to motion caused by two surfaces rubbing against each other
• gravity: the force that one massive object exerts to attract another object to it; expressed as the weight of an object
• magnitude: the size or quantity of something
• net force: the sum of all of the forces acting on an object
• normal force: support force at a right angle to the surface
• normal force: the support force a surface exerts on an object; always at a 90° angle to the surface
• unbalanced force: when forces acting in opposite directions are unequal
• vector: a quantity that has both a size and a direction

Supporting Words
• magnitude: size

Advanced Words
• newton: a scientific measurement for force

Lesson 6: Friction

On-level Words
• air resistance: a type of fluid friction caused by gas molecules pushing against objects moving through air
• fluid friction: acts on solid objects as they move through a fluid
• friction: a contact force that resists motion that objects exert on each other when they rub together
• kinetic: relating to movement or motion
• microscopic: relating to objects or details so small that they can be seen only with a microscope
• static: the state of remaining constant; not changing or moving
• traction: the grip of one object on another

Supporting Words
• roughness: bumps and grooves that increase traction

Advanced Words
• aerodynamic: how easily an object is able to move through the air
• lubricant: substance that reduces friction by filling in the bumps and grooves between objects
Lesson 7: Gravity

On-level Words

- directly proportional: a relationship between variables in which an increase (or decrease) in one variable causes an increase (or decrease) in the other variable
- free fall: a state in which the only force acting on an object is the force of gravity
- gravity: the force that one massive object exerts to attract another object to it; expressed as the weight of an object
- inversely proportional: a relationship between variables in which an increase in one variable causes a decrease in the other variable, or a decrease in one variable causes an increase in the other
- projectile motion: the curved motion that results from the combination of an object’s horizontal inertia and the gravitational force pulling the object downward
- terminal velocity: the fastest speed a falling object can reach; occurs when air resistance becomes equal to the force due to gravity
- universal law of gravitation: the law that says that any two objects in the universe are attracted to each other and that the force of attraction between the two objects is affected by the masses of the two objects and the distance between the two objects
- vacuum: a space that contains no matter (even air)

Supporting Words

- weight: force due to gravity

Advanced Words

- influence: being able to indirectly affect something

Lesson 8: Newton’s Laws of Motion

On-level Words

- action force: the force of an object acting on another object
- inertia: the property of matter that resists change in motion
- Newton’s first law of motion: an object at rest stays at rest, and an object in motion stays in motion, unless acted on by an unbalanced force
- Newton’s second law of motion: the total net force acting on an object is equal to mass times acceleration (F = ma)
- Newton’s third law of motion: for every action, there is an equal and opposite reaction
- reaction force: the force of an object responding to and resisting the force of another object

Supporting Words

- relate: to show or explain a connection between two concepts
Advanced Words

- eject: to throw out by physical force
- orbit: a circular path around an object

Lesson 9: Lab: Newton’s Laws of Motion

On-level Words

- acceleration: the rate of change of velocity; velocity per unit of time
- force: a push or a pull
- inertia: property of matter that resists change in motion

Supporting Words

- impact: to hit with force

Advanced Words

- qualitative: expressed in terms of quality

Lesson 10: Momentum

On-level Words

- action force: the force of an object acting on another object
- action-reaction force pair: when two objects interact with each other using action and reaction forces
- law of conservation of momentum: the total momentum of all interacting objects is the same before and after an event
- momentum: the measure of the motion of an object found by multiplying the object’s mass and velocity
- vector: a quantity that has both a size and direction
- reaction force: the force of an object responding to and resisting the force of another object

Supporting Words

- opposite: being in a position to oppose

Advanced Words

- collision: the act of coming together with solid impact
- explosion: a violent and forceful burst
UNIT 7: WORK, POWER, AND ENERGY

Lesson 1: Work and Power

On-level Words

- joule: the metric unit used to measure work, which equals one newton meter
- oppose: to resist or work against
- power: the rate at which work is done
- watt: the metric unit used to measure power, which equals one joule per second
- work: the use of force to move an object

Supporting Words

- time: a measurable period for when something occurs.

Advanced Words

- component: a part of something
- factor: one of a number of things that contribute to a result

Lesson 2: Introduction to Energy

On-level Words

- chemical potential energy: the energy stored in the bonds of atoms
- elastic potential energy: the energy stored in a compressed or stretched object
- electrical energy: the energy due to the flow of electrical charges
- electromagnetic wave: a type of wave that carries energy through space, where there is almost no matter
- energy: the ability to do work
- gravitational potential energy: the energy of an object due to its height above a surface
- internal energy: the total potential and kinetic energies of the particles in a substance
- kinetic energy: the energy an object has due to its motion
- mechanical energy: the energy of an object due to its potential energy and kinetic energy
- nuclear energy: the energy stored in the nucleus of an atom
- potential energy: the stored energy an object has due to its position
- radiant energy: the energy associated with electromagnetic waves
- thermal energy: the part of total internal energy that can be transferred
- wave: a disturbance that carries energy from one place to another through matter and space

Supporting Words

- compress: to press in to make more compact
- scale: a comparison of size
Advanced Words

- transform: to completely change, as in composition, structure, or character

Lesson 3: Potential and Kinetic Energy

On-level Words

- kinetic energy: the energy an object has due to its motion
- potential energy: the stored energy an object has due to its position
- system: a group of related objects that interact and form a complex whole
- total energy: the total amount of potential and kinetic energy in a system
- transformation: a change in form, appearance, nature, or characteristic

Supporting Words

- system: a group of related objects that interact and form a complex whole

Advanced Words

- static: still and unmoving

Lesson 4: Lab: Kinetic Energy

On-level Words

- kinetic energy: the energy an object has due to its motion
- linear: forming a straight line
- nonlinear: not forming a straight line
- potential energy: the stored energy an object has due to its position
- speed: the distance traveled per unit of time
- velocity: a displacement per unit of time; distance traveled per unit of time in a specific direction

Supporting Words

- consistent: unchanging in behavior
- uniform: the same as others

Advanced Words

- lever: a type of simple machine used for changing the direction of applied force
Lesson 5: Energy Transformations

On-level Words

- energy conversion: the process of changing one form of energy to another
- fossil fuels: fuels such as coal, oil, and natural gas that formed from the remains of prehistoric plants and animals
- law of conservation of energy: the principle that energy cannot be created or destroyed; the total amount of energy in the universe is always the same
- turbine: a machine in which moving gas or liquid is used to turn a wheel or cylinder

Supporting Words

- fission: the splitting apart of an object
- fusion: the melding together of two or more objects

Advanced Words

- generator: a machine that transforms mechanical energy into electrical energy

Lesson 6: Introduction to Machines

On-level Words

- efficiency: the ratio of output work to input work expressed as a percentage
- input: the amount of something put into a machine or system
- machine: a device that makes work easier
- mechanical advantage: the ratio of output force to input force
- output: the amount of something that comes out of a machine or system
- ratio: a comparison of two amounts calculated by dividing one amount by the other

Supporting Words

- component: an essential part

Advanced Words

- exert: to put forth an action

Lesson 7: Simple Machines

On-level Words

- compound machine: a device that consists of two or more simple machines operating together
- mechanical advantage: a calculation of how much a machine multiplies a force, or the ratio of output force to input force
- pulley: a grooved wheel and rope that changes the direction of a force
• simple machine: one of six devices that have few or no moving parts and make work easier
• spiral: to coil around an axis or an object
• transmit: to move force or energy from one medium or part of a mechanism to another

Supporting Words
• concentrate: to fix effort on one goal

Advanced Words
• fulcrum: a fixed point

Lesson 8: Earth’s Energy Budget

On-level Words
• absorption: the taking in of a wave by an object as the wave hits an object
• atmosphere: the mixture of gases surrounding Earth
• evaporation: vaporization that occurs at the surface of a liquid
• greenhouse effect: a natural process by which Earth’s surface and lower atmosphere are warmed by certain gases in the atmosphere, helping to maintain the normal range of temperatures on Earth
• greenhouse gases: the gases that absorb heat released by Earth’s surface and rerelease this heat into the atmosphere, warming Earth
• reflection: the bouncing of a wave after the wave hits an object
• solar radiation: the radiant energy that comes from the Sun
• system: a group of related objects that interact and form a complex whole
• texture: the way the surface of an object feels

Supporting Words
• budget: an amount of something used for a purpose

Advanced Words
• convection: the transfer of thermal energy due to the movement of a liquid or a gas
• disperse: to be widely spread out
Lesson 9: Nonrenewable Resources

On-level Words

- abundant: existing in great supply; plentiful
- conserve: to protect from loss or harm; to preserve for future use
- nonrenewable resource: a natural resource that is available in limited amounts and can be used up
- ore: a rock that contains a metal or other element in useful amounts and can be mined

Supporting Words

- natural: as from nature; is renewable

Advanced Words

- process: to change or prepare something using special treatment

Lesson 10: Renewable Resources

On-level Words

- geothermal: the heat produced from within the earth
- hydroelectricity: electricity generated from running water
- imbalance: a situation in which two things that normally are equal become unequal
- renewable resources: a natural resource available in abundance or that can be replaced as quickly as it is used
- reservoir: a supply of water, petroleum, natural gas, or other resource stored in a large area such as a lake

Supporting Words

- solar: relating to the Sun
- wind: the movement of the air

Advanced Words

- geyser: a spring that periodically shoots out hot water and steam
UNIT 8: THERMAL ENERGY AND HEAT

Lesson 1: Temperature and Thermal Energy

On-level Words

- absolute zero: a theoretical temperature at which the motion of all atoms and molecules stops; the coldest possible temperature
- convert: to change from one form or system to another
- internal energy: the total potential and kinetic energies of the particles in a substance
- scale: a series of marks and numbers that is used for measurement
- temperature: a measure of the average kinetic energy of all of the particles in a substance
- thermal energy: the part of total internal energy that can be transferred
- thermometer: a tool used to measure temperature

Supporting Words

- thermal: relating to heat or caused by heat

Advanced Words

- Celsius: scale of temperature based on the freezing and boiling points of water
- Fahrenheit: scale of temperature based on the temperature of the human body and the temperature of an icy salt-water mixture
- Kelvin: scale of temperature based on absolute zero

Lesson 2: Heat

On-level Words

- converge: to move toward; come together
- heat: the thermal energy that flows from one substance to another due to a temperature difference
- specific heat: the amount of heat required to change the temperature of 1 gram of a substance by 1°C
- thermal equilibrium: the state in which no thermal energy transfer occurs because both substances are at the same temperature

Supporting Words

- contact: the touching of surfaces

Advanced Words

- transfer: to move to another place
Lesson 3: Conduction

On-level Words

- conduction: the transfer of thermal energy or electric charge by direct contact
- conductor: a material that allows electricity or thermal energy to easily move through it
- insulator: a material that allows little electricity or thermal energy to move through it

Supporting Words

- vibrate: rapid back and forth movement

Advanced Words

- ceramic: an object made from a nonmetallic mineral by heating at high temperatures

Lesson 4: Convection

On-level Words

- convection: the transfer of thermal energy due to the movement of a liquid or gas caused by differences in temperature
- convection current: the circular motion of a fluid caused by temperature and density differences
- large-scale: involving a large area
- magma: the molten rock beneath Earth’s surface
- small-scale: involving a small area

Supporting Words

- density: the amount of mass in a given volume

Advanced Words

- circulation: movement of something through a circuit

Lesson 5: Radiation

On-level Words

- absorber: a material that takes in a wave when the wave hits it
- electromagnetic wave: a type of wave that carries energy through space where there is almost no matter
- radiation: the transfer of thermal energy by electromagnetic waves
- reflector: a material that causes a wave to bounce off it
- texture: the way the surface of an object feels
- wave: a disturbance that carries energy from one place to another through matter and space
Supporting Words

- vacuum: a space that is empty of matter

Advanced Words

- thermography: technology that uses a camera to show variations in temperature as color

Lesson 6: Lab: Thermal Energy Transfer

On-level Words

- heat: the thermal energy that flows from one substance to another due to a temperature difference
- joule: the metric unit used to measure work, which equals one newton meter
- specific heat: the amount of heat required to change the temperature of 1 gram of a substance by 1°C
- thermal energy: the part of total internal energy that can be transferred
- thermal equilibrium: the state in which no thermal energy transfer occurs because both substances are at the same temperature

Supporting Words

- controlled experiment: an experiment in which only one variable is changed at a time

Advanced Words

- calorimeter: device that measures the transfer of the thermal energy of material to the environment in the chamber
UNIT 9: WAVES, SOUND, AND LIGHT

Lesson 1: Introduction to Waves

On-level Words

- amplitude: the height of the wave from the midpoint to the highest point (crest) or the lowest point (trough)
- crest: the highest point on the wave
- distinguish: to recognize the differences between objects or concepts
- electromagnetic wave: a type of wave that carries energy through space where there is almost no matter
- longitudinal wave: a type of wave that transfer energy parallel to the direction of wave motion
- mechanical wave: a type of wave that carries energy through matter
- parallel: to travel or extend in the same direction as something
- perpendicular: to be at a $90^\circ$ angle (or right angle) from something
- transverse wave: a type of wave that transfer energy perpendicular to the direction of wave motion
- trough: the lowest point on the wave
- wave: a disturbance that carries energy from one place to another through matter and space
- wavelength: the distance from one crest to the next crest or one trough to the next trough in a wave

Supporting Words

- ray: a beam of energy

Advanced Words

- exposure: being unprotected or at risk

Lesson 2: Properties of Waves

On-level Words

- amplitude: for a transverse wave: the height of the wave from the midpoint to the highest point (crest) or the lowest point (trough); for a longitudinal wave: the amplitude is related to how close together the particles of matter of the medium are at the compression of the wave
- compression: the part of a longitudinal wave where the particles of the matter that the wave moves through are closer together
- crest: the highest point on the wave
- electromagnetic spectrum: the range of wavelengths and frequencies of electromagnetic waves
- frequency: the number of wavelengths that passes a fixed point in a second
• hertz: a unit used to express frequency of a wave; one hertz is equal to one wavelength per second
• medium: the material or substance a wave moves through
• period: the amount of time it takes for a wavelength to pass a certain point
• rarefaction: the part of a longitudinal wave where the particles of the matter the wave moves through are farther apart
• trough: the lowest point on the wave

Supporting Words

• speed: the distance traveled per unit of time
• temperature: the degree of how hot or cold something is

Advanced Words

• direct relationship: when two variables increase or decrease with the other
• indirect relationship: when one variable increases while the other decreases

Lesson 3: Wave Interactions

On-level Words

• absorption: the taking in of a wave by an object as the wave hits the object
• constructive interference: a type of interference in which waves build on each other to form a bigger wave
• destructive interference: a type of interference in which waves break each other down to form a smaller wave or cancel each other out, resulting in no wave formation
• diffraction: the bending and scattering of a wave as it hits an object or goes through an opening
• incident wave: a wave that is moving toward an object
• interference: the phenomenon that occurs when two waves meet while traveling along the same medium
• normal: a line that forms a 90° angle to a surface
• reflection: the bouncing of a wave after it hits an object
• refraction: the bending of a wave as it passes through one medium to another medium
• transmission: the passing of a wave through an object

Supporting Words

• angle: the space formed by two intersecting lines where they meet

Advanced Words

• phenomenon: an event or occurrence
Lesson 4: Sound Waves

On-level Words

- amplitude: the density of the medium’s particles at the compression of the wave
- compression: the part of a longitudinal wave where the particles of the matter that the wave moves through are closer together
- frequency: the number of wavelengths that pass a fixed point in a second
- medium: the material or substance a wave moves through
- rarefaction: the part of a longitudinal wave where the particles of the matter the wave moves through are farther apart
- vibrate: to move back and forth quickly and steadily
- wavelength: the distance between a compression and the compression next to it, or a rarefaction and the rarefaction next to it

Supporting Words

- speed: the distance traveled per unit of time
- travel: to move from one place to another

Advanced Words

- differentiate: to see the differences between two substances

Lesson 5: Properties of Sound

On-level Words

- decibel: the unit of measurement for intensity of sound
- Doppler effect: the changing of the pitch of a sound as it moves by a stationary hearer
- frequency: the number of wavelengths that pass a fixed point in one second
- hertz: a unit used to express frequency of a wave
- intensity: the amount of energy a sound wave has per unit of time
- natural frequency: the frequency at which an object vibrates when struck
- pitch: the highness or lowness of a sound
- resonance: the phenomenon by which one object is made to vibrate by another object with similar frequency
- sound quality: the description of the differences between sounds that have the same pitch and loudness
- standing wave: the wave that is produced when two waves, which are traveling in opposite directions and have the same amplitude and wavelength, meet each other
- stationary: not moving
- tension: the tightness of the stretch of a string
Supporting Words

- kidney stone: hard mass of chemicals found in the kidney
- siren: a device that produces a loud, shrill warning sound

Advanced Words

- disturbance: the act of interfering with
- magnified: enlarged

Lesson 6: Using Sound

On-level Words

- analog signal: a signal that carries information by copying the original sound
- digital signal: a signal that carries information by changing the original sounds into numbers
- echo: a copied sound that comes back to the source of the sound after reflecting or bouncing off a surface
- echolocation: a method used by animals for navigation and finding food
- technology: the application of new methods or devices to solve problems
- ultrasound: a technology that uses high-frequency sound waves

Supporting Words

- industry: the manufacture of products or services

Advanced Words

- acoustic: relating to sound or hearing
- diagnose: to recognize an ailment using signs or symptoms

Lesson 7: The Electromagnetic Spectrum

On-level Words

- electromagnetic spectrum: the entire range of electromagnetic radiation, including all its wavelengths
- electromagnetic wave: a type of wave that carries energy through space where there is no matter
- fluorescence: the emission of light by a substance after it has absorbed energy from electromagnetic waves
- imaging: the process of creating a visual representation of an object, usually by exposure to specific electromagnetic waves

Supporting Words

- visible: able to be seen
Advanced Words

- transmit: to transfer from one place to another
- radioactive decay: the change of a radioactive element into a different element at a fixed rate

Lesson 8: Properties of Light

On-level Words

- opaque: does not allow light to pass through; unable to see through
- reflect: to bounce off of
- refract: to bend
- speed of light: the speed all electromagnetic waves travel in space, 3 x 10^8 m/s
- transparent: allows most light to pass through

Supporting Words

- electromagnetic wave: a type of wave that carries energy through space where there is almost no matter
- magnetic field: the area around a magnet where magnetic forces can be detected
- mechanical wave: a type of wave that carries energy through matter
- particles: very small parts or pieces of something
- rainbow: an arc of colors caused by sunlight shining through a refractive substance

Advanced Words

- prism: an object that separates light passing through it by wavelength, forming a rainbow

Lesson 9: Reflection and Mirrors

On-level Words

- concave: a mirror or lens that curves inward
- convex: a mirror or lens that curves outward
- law of reflection: the principle that the angle of incidence is equal to the angle of reflection
- normal: a line that forms a 90° angle to a surface
- real image: an image that appears to be on the same side of the mirror as the object
- virtual image: an image that appears to be on the opposite side of the mirror from the object

Supporting Words

- polished: a smoothed surface

Advanced Words

- angle of incidence: the angle between the incoming ray of light and the normal
Lesson 10: Refraction and Lenses

On-level Words

- converge: to move toward; come together
- diverge: to move apart; separate
- focal length: the distance from a convex lens at which rays converge; the distance from a concave lens from which rays appear to diverge
- prism: a transparent object that has at least two sides that are not parallel and can refract light
- refraction: an abrupt change in direction at the boundary between two media

Supporting Words

- density: the amount of mass in a given volume

Advanced Words

- lens: a clear, curved material that refracts light to form an image

Lesson 11: Using Light

On-level Words

- fiber optic: a long, thin strand of glass or plastic that allows light to travel through it
- laser: a device that produces a beam of strong, concentrated light of only one wavelength
- magnify: to make an object appear larger
- reflecting telescope: a telescope that gathers and focuses light from distant objects using mirrors and lenses
- refracting telescope: a telescope that gathers and focuses light from distant objects using lenses

Supporting Words

- sensor: a device that detects a physical property

Advanced Words

- halo: a circle of rainbow colors around an image that occurs in a refracting telescope due to the slowing down of wavelengths that pass through the lens
UNIT 10: ELECTRICITY AND MAGNETISM

Lesson 1: Electric Charge

On-level Words

- attract: to pull toward
- conduction: the transfer of thermal energy or electric charge by direct contact
- electric field: the area around a charged object where the object can exert a force on other charged objects
- electrical force: a force between two charged ions, objects, or particles
- induction: the transfer of electric charge without direct contact
- repel: to push away from
- static discharge: the movement of electric charges off an object
- static electricity: the buildup of electric charges on an object

Supporting Words

- friction: the transfer of electric charge by rubbing

Advanced Words

- Van de Graaff generator: a device that accumulates static charge to produce a spark

Lesson 2: Electric Current

On-level Words

- ampere: the basic unit of electric current
- conductor: a material that allows electricity or thermal energy to easily move through it
- electric current: the flow of charge through a wire or other material
- electric potential: the potential energy an electric charge has due to its location in relation to other electric charges
- insulator: a material that allows little electricity or thermal energy to move through it
- ohm: the unit of resistance
- potential difference: the difference in electric potential energy between two different points; also called voltage
- resistance: the tendency of a material to oppose the flow of electrons
- semiconductor: a material that is able to conduct electricity better than insulators but not as well as conductors
- superconductor: a material that has zero resistance when it is at a very low temperature
- volt: the unit of electric potential difference
Supporting Words

- wire: a metal thread or rod used to conduct electricity

Advanced Words

- ammeter: a device that measures current
- ohmmeter: a device that measures resistance
- voltmeter: a device that measures voltage

Lesson 3: Ohm’s Law

On-level Words

- electric circuit: a path through which electric charges can travel
- Ohm’s law: the law that states resistance is equal to voltage divided by current

Supporting Words

- outlet: an electrical device that an appliance can plug into

Advanced Words

- appliance: a device designed for a specific use

Lesson 4: Electric Circuits

On-level Words

- circuit diagram: illustrated representation of an electric circuit
- closed circuit: an electric circuit with a closed switch, so current can flow
- open circuit: an electric circuit with an open switch, so current cannot flow
- parallel circuit: an electric circuit that has multiple branches for the current to travel
- series circuit: an electric circuit that has only one path along which the current can travel

Supporting Words

- power source: a source of electrical energy
- switch: a device to help control the flow of electric charge running through a circuit
- symbol: a mark that stands for something else

Advanced Words

- disconnected: separated
Lesson 5: Magnets and Magnetism

On-level Words

- align: to face the same direction
- magnetic field: the area around a magnet where the magnet can exert a force on objects containing certain metals
- magnetic pole: the end of a magnet where the force is the strongest
- magnetism: the force a magnet exerts to attract or repel other objects

Supporting Words

- attract: pull together
- repel: push apart

Advanced Words

- aurora: a phenomenon that occurs when solar winds align with Earth’s magnetic field
- Maglev train: a train that travels due to the levitation of magnets

Lesson 6: Lab: Magnetic and Electric Fields

On-level Words

- charge: positive or negative electrical energy
- electric current: the flow of charge through a wire or other material
- electron: a negatively charged particle that orbits the nucleus of an atom
- field: a region or space in which a given effect exists
- magnetism: the force a magnet exerts to attract or repel other objects

Supporting Words

- compass: a device that is used to find magnetic north

Advanced Words

- ferrofluid: magnetic fluids that can be used to demonstrate magnetic fields
- magnetometer: a device used to measure the strength of a magnetic field
Lesson 7: Electromagnetism

On-level Words

- electromagnet: a strong magnet created by wrapping a metal core in a solenoid
- electromagnetic induction: a process that produces a current by moving a wire through a magnetic field
- induce: to cause
- solenoid: a current-carrying wire with many loops

Supporting Words

- loop: circular fold that allows something to be passed through or inserted

Advanced Words

- Compact Muon Solenoid: a large solenoid that produces a magnetic field stronger than Earth’s, and used to conduct experiments on atom collisions

Lesson 8: Applications of Electromagnetism

On-level Words

- alternating current (AC): a current that repeatedly changes direction at regular intervals
- armature: the rotating part of an electric motor or generator that consists of many loops of wire wrapped around an iron core
- brush: a part in a motor or generator that is the contact point for a commutator or a slip ring and allows current to flow in or out of a motor or generator
- commutator: a part in a motor attached to the armature that provides a path for current to flow into armature, allowing the current to change direction
- direct current (DC): a current that constantly flows only in one direction
- electric generator: a device that converts kinetic energy into electrical energy
- electric motor: a device that converts electrical energy into kinetic energy to turn an axle
- slip ring: a part in a generator attached to the armature that provides a path for current to flow from the armature

Supporting Words

- electric motor: a device that converts electrical energy into kinetic energy and turns an axle using a magnetic field

Advanced Words

- rotation: turning as if on a pivot
REAL-WORLD APPLICATIONS AND SCIENTIFIC THINKING

Throughout the course, students participate in 15 labs and 21 projects that engage them in scientific thinking and provide opportunities to apply concepts they learn into real-world settings. This is important, as science is crucial to developing critical-thinking skills, as well as understanding the fundamentals of how the world works, which is necessary for many careers and is useful in anyone’s day-to-day life.

The following descriptions show examples of how students explore real-world applications and employ scientific thinking.

UNIT 1: ATOMS AND THE PERIODIC TABLE

1. In the lesson Periodic Table, students obtain accurate data on a chosen element using their knowledge of the lesson material such as type of element, atomic number, atomic mass, group, and period. They identify and describe its physical and chemical properties as well as information about the discovery of the element. Students describe where and how the element is obtained for use. Last, students describe how it is used. This project shows students how an element they may be unfamiliar with is constantly utilized in their everyday lives, and that compounds they know of can be very different from the element in its pure form (for example studying chlorine when the students are used to table salt). This reinforces the importance of studying the periodic table and shows how most elements are already a large part of the student’s real life. Students develop their communication skills as they develop this information into a multimedia presentation and present it to their peers and teacher.

2. In the lessons Metals, Nonmetals, and Metalloids, students learn about the different properties associated with these three element types, and then observe photographs or read descriptions to identify the type of element. This is a fundamental part of science: the observation of natural phenomena to understand the world around us. Students learn that being able to predict behavior of materials is useful in selecting materials for use, such as in designing tracks for a new transportation system, or finding an insulator. After these lessons are completed, the observation exercises will have assisted the student to better comprehend differences in properties between element types. A real-world application of this is that miners need to tell the difference between the metal ore to be mined and the nonmetal rock to be avoided.

UNIT 2: STATES AND PROPERTIES OF MATTER

1. Students are likely already familiar with state changes, such as boiling water or melting ice, but the lesson Changes of State explains why these changes occur, how to predict them, and how to cause them.

2. In the lesson Density and the lesson Lab: Density of Solids, students learn how to calculate the density, mass, and volume of differently shaped objects, including rectangular prisms, cylinders, cones, spheres, and irregularly shaped solids. These are all shapes that students interact with in real life, including mail packages, basketballs, and pipes. The students also identify an unknown solid, finding its density.
UNIT 3: CHEMICAL BONDING AND COMPOUNDS

1. In the lesson Polymers, students learn how monomers combine to form polymers, which have unique and useful properties. What may surprise students is how prevalent polymers are in their lives, including plastic, clothing (cotton, wool, and silk), tires, paper, many foods, etc. They also learn the difference between natural and synthetic polymers, and how the use of synthetic polymers, including plastic, has a negative impact on nature. After the lesson, they further their understanding of polymers in real-world situations by reading scientific articles.

2. Understanding and incorporating a systematic approach to names is a defining part of science, as it removes subjectivity and allows everyone to fully understand the meaning of the name. In the lessons Naming Ionic Compounds and Naming Covalent Compounds, students learn the scientific reasons behind chemical names, which they can then use in real life, such as understanding the list of ingredients in the foods they eat.

UNIT 4: CHEMICAL REACTIONS

1. In the lesson Types of Chemical Reactions, students learn about different types of chemical reactions, including synthesis, oxidation, combustion, decomposition, and replacement reactions, and then apply them to real-world situations such as baking and the formation of rust.

2. After the lesson Introduction to Chemical Reactions, students conduct an investigation to explore how a change in temperature during a chemical reaction can be used to classify the reaction as endothermic or exothermic. In addition, after the lesson Types of Chemical Reactions, students use their knowledge on how chemical processes work to engineer a device using chemical processes to regulate the release of thermal energy.

UNIT 5: MIXTURES, SOLUTIONS, AND ACID-BASE REACTIONS

1. Students use many real-world examples in this unit. Starting in the lesson Mixtures, students identify homogenous mixtures, such as soda, and heterogeneous mixtures, such as salad dressing and sand. In the lesson Separation of Mixtures, students learn how mixtures can be separated using a screen (such as from a clothes dryer), a filter (such as in water purification), and others. Later in the unit, students are introduced to acids and bases in the lesson Properties of Acids and Bases, common examples of which are vinegar, soap, laundry detergent, citrus fruits, and baking soda.

2. In the lesson Lab: Acids and Bases, students study concentrations of H+ and OH- ions in laundry detergent and vinegar solutions. By diluting each solution, students are able to observe the change in pH using pH indicators.
UNIT 6: MOTION AND FORCES

1. In the lesson Gravity, students learn about projectile motion, and how an object will travel in an arc due to the horizontal force of the throw and the downward force of gravity. This directly relates to students in sports, such as basketball and football, as these athletes must inherently take projectile motion into consideration to make a basket or a goal. In addition, the labs Lab: Motion and Lab: Newton’s Laws of Motion have students analyzing the movement of toy cars to understand how physics plays a direct role on the performance of the car. In real life, car manufacturers must take into consideration similar factors, such as friction, inertia, and momentum, to design safe, high-performance cars.

2. In the lesson Momentum, students tie in what they learned from previous lessons to understand how all forces discussed in the unit interact. Students then use this knowledge to engineer a way to keep an egg safe when dropped from a designated height. To do this, students must be aware of all forces involved and be able to solve calculations using force, speed, mass, velocity, acceleration, and momentum.

UNIT 7: WORK, POWER, AND ENERGY

1. In the lessons Introduction to Machines and Simple Machines, students are introduced to the scientific definition of “machine” and identify real-world examples, such as cars, bikes, and hand tools. Students then develop their understanding of machines by learning about the simplest kinds, how they are used, and their benefits. These lessons show that machines can be found anywhere, including the human body.

2. In the lesson Potential and Kinetic Energy, students observe and examine potential and kinetic energy by designing parts of a roller-coaster track and explaining the energy of the roller-coaster cart at different points on the track. In the lesson Lab: Kinetic Energy, students engineer a contraption to test the kinetic energy of a beanbag propelled upward by dropping a bottle on a lever.

UNIT 8: THERMAL ENERGY AND HEAT

1. In the lessons Conduction, Convection, and Radiation, students learn how heat transfers through objects they are familiar with, such as boiling water, the heat of a fire, and the warmth of a hot beverage. Conductors and insulators are introduced, and students identify why some objects are constructed out of specific materials based on their uses, such as insulating oven mitts and conducting radiators. Finally, students learn that these methods of heat transfer are fundamental to our planet, from how we receive heat from the Sun to how clouds and storms occur.

2. In the lesson Radiation, students use their knowledge of radiation, conduction, and the reflection and absorption of heat to design and construct a slow cooker. The activity involves students performing independent research, designing and building the slow cooker, performing experimental tests, and illustrating a final design based on the results of testing.
UNIT 9: WAVES, SOUND, AND LIGHT

1. In the lesson Using Sound, students learn about the uses of ultrasound, which is used in the medical field by monitoring unborn babies, breaking down kidney stones, and observing internal damage. Students also learn that ultrasound is used in industry to increase the efficiency of manufacturing products, to identify broken machinery for replacement, and destroy water-borne bacteria to make water safe to drink.

2. In the lesson Properties of Light, students complete an assignment in which they develop illustrative models for how mechanical and electromagnetic waves are transmitted, reflected, and absorbed through multiple materials. Students require a thorough understanding of the movement of both mechanical and electromagnetic waves to be able to successfully complete the assignment.

UNIT 10: ELECTRICITY AND MAGNETISM

1. In the lesson Electric Current, students investigate how electric currents operate using conductors, resistors, and electrical potential. In this lesson, students learn how common, real-world technologies work such as light bulbs and computer microchips. In the lesson Applications of Electromagnets, students enhance their knowledge further by exploring how many real-world devices operate using electromagnets, such as doorbells, audio speakers, Maglev trains, cranes, electric motors, and electric generators, as well as the difference between alternating current, which supplies electricity to homes, and direct current, which is used in batteries.

2. In the lesson Electromagnetism, students utilize their engineering skills to develop and build a working circuit using a magnet and iron filings to test the effect of an electric current on a magnetic field. After the experiment, students compile their results and enhance their scientific literary skills by writing a scientific lab report.
**CROSSCUTTING CONCEPTS**

Students encounter crosscutting concepts as they are integrated into the lessons. The following examples show how students use crosscutting concepts in each of the units throughout the course.

### UNIT 1: ATOMS AND THE PERIODIC TABLE

<table>
<thead>
<tr>
<th>Crosscutting Concept</th>
<th>Unit Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patterns</strong>: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>The lessons Metals, Nonmetals, and Metalloids show students that these three types of elements have observable traits that allow them to be easily classified and organized. Students examine patterns in the periodic table that group these types together. They discover where the similarities and differences are between the groups and periods.</td>
</tr>
<tr>
<td><strong>Cause and Effect</strong>: Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>Reactions between atoms are a direct cause of the number of electrons found in an atom’s valence shell. Reactive strength can also be influenced by the size of the atom. This concept is discussed in the lessons Elements and Periodic Table, where students learn to predict the likelihood of a reaction by first identifying the number of electrons present in an atom’s outermost valence shell.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity</strong>: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>The lesson Periodic Table introduces students to the concept that 1.) Elements in a period are similar in size from one to the next, but have different properties due to different numbers of electrons in the valence shell, and 2.) Elements in a group have similar properties due to the same number of valence electrons, but have different levels of reactivity due to atom size.</td>
</tr>
<tr>
<td><strong>Systems and System Models</strong>: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>In the lesson Periodic Table, students are introduced to the periodic table, which is an organized chart of the known elements. The structure of this model allows students to examine the placement of elements in the table and use this information to understand and predict the behavior of specific elements.</td>
</tr>
<tr>
<td><strong>Energy and Matter: Flows, Cycles, and Conservation</strong>: Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>Thermal and electric conductivity and insulation, as well as the concept of semiconduction, are introduced in the lessons Metals, Nonmetals, and Metalloids. These concepts help to teach students about the behavior of these element types based on the flow of thermal and electric energy.</td>
</tr>
</tbody>
</table>
**Structure and Function:** The way an object is shaped or structured determines many of its properties and functions.

The structure of an atom, including its subatomic particles, determines most of its properties and behaviors. In the lessons **Atoms** and **Elements**, students learn about basic atomic structure and then build on this knowledge in later lessons.

**Stability and Change:** For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

In the lessons **Elements** and **Periodic Table**, students are introduced to the concept that some elements are more reactive than others. For instance, the halogens are the most reactive group in the table, whereas the noble gases are the most stable. This is due to the number of electrons in the atom’s valence shell.
## Unit 2: States and Properties of Matter

<table>
<thead>
<tr>
<th>Crosscutting Concept</th>
<th>Unit Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patterns:</strong> Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>In the lessons States of Matter, Changes of State, and Physical Properties, students learn about different states of matter, their properties, and how states change into other states. These properties are constant in nature and assist students in classifying states and understanding how, when, and why they change.</td>
</tr>
<tr>
<td><strong>Cause and Effect:</strong> Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>State changes, such as from a solid to a liquid or a liquid to a gas, are caused by changes in temperature and pressure. In the lesson Changes of State, students learn about these relationships and why they happen.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity:</strong> In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>In the lesson Changes of State, students learn that state changes are caused by changes in temperature and pressure at certain scales. Understanding the effect that certain temperatures and pressures have on states of matter allows students to predict state changes.</td>
</tr>
<tr>
<td><strong>Systems and System Models:</strong> A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>In the lesson States of Matter, students organize states of matter based on the movement of their component atoms and do an activity in which they create a model of the water cycle.</td>
</tr>
<tr>
<td><strong>Energy and Matter: Flows, Cycles, and Conservation:</strong> Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>In the lesson Changes of State, students observe the flow of matter from different states through a system, which helps to understand the system’s behavior. For instance, a change of state from a solid to a liquid, such as the melting of an ice cube, may mean that temperature has increased.</td>
</tr>
<tr>
<td><strong>Structure and Function:</strong> The way an object is shaped or structured determines many of its properties and functions.</td>
<td>In the lesson States of Matter, students learn how the structure of molecules in a substance relates to its state. For example, molecules in a gas are loose and can move freely, but molecules in a solid are packed together and movement is constricted.</td>
</tr>
</tbody>
</table>
**Stability and Change**: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

Matter does not change state easily, and remains stable as long as temperature and pressure remain constant. However, enough change in temperature and pressure can cause matter to shift into a new state, which is explained in the lesson *Changes of State*. 

<table>
<thead>
<tr>
<th>Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</th>
<th>Matter does not change state easily, and remains stable as long as temperature and pressure remain constant. However, enough change in temperature and pressure can cause matter to shift into a new state, which is explained in the lesson <em>Changes of State</em>.</th>
</tr>
</thead>
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UNIT 3: CHEMICAL BONDING AND COMPOUNDS

<table>
<thead>
<tr>
<th>Crosscutting Concept</th>
<th>Unit Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patterns:</strong> Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>In the lessons Naming Ionic Compounds and Naming Covalent Compounds, students observe patterns in the meaning of chemical names, how to write chemical names for formulas, and how to read a chemical name to understand the components involved in the compound.</td>
</tr>
<tr>
<td><strong>Cause and Effect:</strong> Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>Bonds form because of the transfer or sharing of electrons, and are based on the number of valence electrons an atom has. In the lessons Ionic Bonds, Covalent Bonds, and Metallic Bonds, students learn about different types of bonds, what causes each, and the properties of each.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity:</strong> In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>In the lesson Polymers, students investigate monomers, polymers, and polymerization, and how the vast quantity, or scale, of connected monomers in a polymer affects the overall properties of the polymer.</td>
</tr>
<tr>
<td><strong>Systems and System Models:</strong> A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>A compound is an organized group of atoms, and every compound of a substance is identical. In the lesson Compounds, students learn about compounds and different models used to help interpret its structure and bonds, such as the ball-and-stick model and the space-filling model.</td>
</tr>
<tr>
<td><strong>Energy and Matter: Flows, Cycles, and Conservation:</strong> Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>In the lesson Lab: Ionic and Covalent Bonds, students observe the differences between properties of ionic and covalent bonds firsthand, including the electrical flow of energy in ionic bonds.</td>
</tr>
<tr>
<td><strong>Structure and Function:</strong> The way an object is shaped or structured determines many of its properties and functions.</td>
<td>The compounds of a particular substance, such as water, are identical in atomic structure. In the lessons Ionic Bonds and Covalent Bonds, students learn about the compounds of different substances, how they bond, and how their structure affects their properties. For example, ionic bonds form by transferring electrons between atoms, but covalent bonds form when electrons are shared instead of transferred.</td>
</tr>
<tr>
<td>Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</td>
<td>Atoms with full valence shells are nonreactive, and are therefore stable. Most atoms do not have full valence shells, and so bond with other atoms to reach stability. This is explained in the lesson Chemical Bonding, by discussing, for example, the octet rule and the electron shell model.</td>
</tr>
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</table>
### Crosscutting Concept

<table>
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<tr>
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<tbody>
<tr>
<td><strong>Patterns:</strong> Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>In the lesson <em>Introduction to Chemical Reactions</em>, students observe different indicators for chemical reactions. While the appearance of a substance may change, the indicators for the reaction will always be the same. Identifying these consistent patterns can act as a guide for the identification of reactants.</td>
</tr>
<tr>
<td><strong>Cause and Effect:</strong> Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>In the lesson <em>Introduction to Chemical Reactions</em>, students learn about types of indicators, which are caused by chemical reactions. They then use these indicators to identify when chemical reactions, rather than physical reactions, have taken place.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity:</strong> In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>Due to the law of conservation of mass, the mass of reactants and products are equal after a reaction has taken place. This is not always obvious when looking at just the compounds involved. The lesson <em>Balancing Chemical Reactions</em> points out the relationship between reactants and products and shows students how to balance equations so that mass is always conserved.</td>
</tr>
<tr>
<td><strong>Systems and System Models:</strong> A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>A chemical reaction is a system whereby reactants form products. This is modeled in <em>Describing Chemical Reactions</em> and <em>Balancing Chemical Reactions</em>. To accurately balance a chemical reaction, students must organize like atoms on each side of an equation to ensure that they are equal.</td>
</tr>
<tr>
<td><strong>Energy and Matter: Flows, Cycles, and Conservation:</strong> Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>In the lesson <em>Balancing Chemical Reactions</em>, students learn that mass must be conserved in a chemical reaction. For a chemical equation, students track the number of atoms on each side of an equation and ensure they are balanced.</td>
</tr>
<tr>
<td><strong>Structure and Function:</strong> The way an object is shaped or structured determines many of its properties and functions.</td>
<td>In the lesson <em>Introduction Chemical Reactions</em>, students learn about different indicators for chemical reactions. The type of indicator, such as color change, heat, or light, is based on what elements make up the compounds and how they are structured.</td>
</tr>
<tr>
<td>Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</td>
<td>In the lesson Rate of Chemical Reactions and the associated lab, students learn firsthand that reactions between compounds can change their rate depending on variables, such as the amount of surface area of reactants and temperature of the system.</td>
</tr>
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</table>
## Unit 5: Mixtures, Solutions, and Acid-Base Reactions

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<tr>
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</thead>
<tbody>
<tr>
<td><strong>Patterns:</strong> Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>In the lesson <em>Properties of Acids and Bases</em>, students observe patterns in different physical properties of substances, including taste and feel, to understand the classification between acids and bases.</td>
</tr>
<tr>
<td><strong>Cause and Effect:</strong> Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>In the lesson <em>Separation of Mixtures</em>, students learn different methods to separate mixtures, and when to use each method. For example, students learn that if blood is used in a centrifuge, the effects will be that the constituents of blood will be separated out.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity:</strong> In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>In the lesson <em>Solubility</em>, students identify the differences between saturation, supersaturation, and unsaturation, and how the quantity of a solute and the solubility of a solvent determine the state of saturation.</td>
</tr>
<tr>
<td><strong>Systems and System Models:</strong> A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>In the lesson <em>Acids and Bases in Solution</em>, students learn the differences between acids and bases in a solution, are introduced to pH, and understand and predict the behavior of acids and bases in a solution.</td>
</tr>
<tr>
<td><strong>Energy and Matter:</strong> Flows, Cycles, and Conservation: Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>The lesson <em>Lab: Acids and Bases</em> encourages students to track the flow of OH⁻ and H⁺ ions in a solution.</td>
</tr>
<tr>
<td><strong>Structure and Function:</strong> The way an object is shaped or structured determines many of its properties and functions.</td>
<td>In the lesson <em>Solubility</em>, students discover how the state and chemical formula of the mixing substances determine the solubility of the substances.</td>
</tr>
<tr>
<td><strong>Stability and Change:</strong> For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</td>
<td>In the lesson <em>Lab: Acids and Bases</em>, students learn about stability and change of an acid and base by diluting stable solutions and monitoring the changes in pH.</td>
</tr>
</tbody>
</table>
### Unit 6: Motion and Forces

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Patterns:</strong> Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>The lesson <em>Newton’s Laws of Motion</em> shows that Newton observed patterns in nature to develop his three laws. These laws still hold true and unchanged 300 years later, which shows that these patterns in nature are consistent and unchanging.</td>
</tr>
<tr>
<td><strong>Cause and Effect:</strong> Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>The lessons <em>Speed and Velocity</em>, <em>Acceleration</em>, <em>Gravity</em>, <em>Newton’s Laws of Motion</em>, and <em>Momentum</em> introduce mathematical equations that show an interaction of concepts such as speed, mass, velocity, acceleration, force, and momentum, and how if any of these are changed, the rest of the equation is also changed to compensate.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity:</strong> In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>Graphs are a great tool to understand how something changes over time. The lesson <em>Speed and Velocity</em> teaches students how to make and read a position vs. time graph, and the lesson <em>Acceleration</em> shows students a velocity vs. time graph. Both graphs are then utilized in the lesson Lab: Motion.</td>
</tr>
<tr>
<td><strong>Systems and System Models:</strong> A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>The lesson <em>Newton’s Laws of Motion</em> and the lesson Lab: Newton’s Laws of Motion show that the world acts on a system of laws that govern the movement of all matter. The lesson and lab identify each law of motion and how all matter follows these laws.</td>
</tr>
<tr>
<td><strong>Energy and Matter: Flows, Cycles, and Conservation:</strong> Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>The lesson <em>Momentum</em> discusses how momentum in a system remains constant (due to the law of conservation of momentum) and shows that by tracking momentum through a collision, the change in velocity and mass can be calculated after a collision has taken place.</td>
</tr>
<tr>
<td><strong>Structure and Function:</strong> The way an object is shaped or structured determines many of its properties and functions.</td>
<td>Friction is a force that is dependent upon the rough surface of two objects rubbing against each other. The lesson <em>Friction</em> demonstrates this by showing that the roughness and weight of an object affect its frictional force.</td>
</tr>
<tr>
<td><strong>Stability and Change:</strong> For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</td>
<td>The lesson <em>Newton’s Laws of Motion</em> teaches students about inertia, which is a stable condition of an object to remain still or remain in motion if no other forces are acted on the object. To change this, an additional force, such as gravity or friction, must occur.</td>
</tr>
</tbody>
</table>
## Unit 7: Work, Power, and Energy

### Crosscutting Concept

<table>
<thead>
<tr>
<th>Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lessons Nonrenewable Resources and Renewable Resources classify natural resources based on if they are limited, regenerative, or non-replaceable, and discuss the importance, benefits, and limitations of each. For example, solar, wind, and water energy all follow the pattern of limited resources, in that they are always present but can be collected in limited quantities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cause and Effect: Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lesson Earth’s Energy Budget talks about how increasing or decreasing greenhouse gases have a direct effect on Earth’s temperature.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</th>
</tr>
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<tbody>
<tr>
<td>The lesson Nonrenewable Resources discusses the quantity of limited resources and why understanding these limits is important to conservation.</td>
</tr>
</tbody>
</table>

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<tr>
<th>Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The lesson Potential and Kinetic Energy shows that potential and kinetic energy are in a system where the increase of one decreases the other, so that the total energy in a system remains constant.</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>Energy and Matter: Flows, Cycles, and Conservation: Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the lesson Energy Transformations, the flow of energy through matter (chemical, mechanical, thermal, electrical, etc.) is introduced and explained. Students learn that energy can be neither created nor destroyed, and so can track energy as it moves through a system.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structure and Function: The way an object is shaped or structured determines many of its properties and functions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The structure of a machine is crucial to understanding its mechanical advantage, which students learn to calculate in the lessons Introduction to Machines and Simple Machines.</td>
</tr>
</tbody>
</table>
**Stability and Change**: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

In the lesson Earth’s Energy Budget, students learn that to maintain the amount of energy on Earth, the energy entering the atmosphere must be equal to the energy leaving. When this is balanced, energy flow is stable. If this becomes unbalanced, such as with the addition of greenhouse gases in the atmosphere, the system undergoes a change.
## UNIT 8: THERMAL ENERGY AND HEAT

<table>
<thead>
<tr>
<th>Crosscutting Concept</th>
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</thead>
<tbody>
<tr>
<td><strong>Patterns:</strong> Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>In the lesson <strong>Temperature and Thermal Energy</strong>, students learn that the temperature scales Fahrenheit, Celsius, and Kelvin were designed based on observed, consistent patterns of temperatures for specific matter. For instance, at sea level, water will always boil at the same temperature, and this pattern resulted in the assignment of this temperature to 100° Celsius.</td>
</tr>
<tr>
<td><strong>Cause and Effect:</strong> Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>Thermal energy flows from matter with a higher temperature to matter with a lower temperature. For instance, if two substances of different temperatures are brought together, then heat will always move from the hotter substance to the cooler one. In the lesson <strong>Heat</strong>, students use this cause-and-effect relationship to predict the flow of thermal energy by understanding the original temperatures of the interacting matter.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity:</strong> In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>In the lesson <strong>Lab: Thermal Heat Transfer</strong>, students perform an experiment involving changing the mass of materials to observe if differently sized materials will absorb thermal energy at different rates.</td>
</tr>
<tr>
<td><strong>Systems and System Models:</strong> A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>In the lesson <strong>Convection</strong>, students learn that convection currents in a fluid transfer heat due to movement. Examples of this are convection in Earth’s systems: the mantle, ocean currents, and clouds and storms in the atmosphere. This lesson includes models of convection, which allow students to predict the behavior of a convection current.</td>
</tr>
<tr>
<td><strong>Energy and Matter: Flows, Cycles, and Conservation:</strong> Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>In the lesson <strong>Convection</strong>, students learn about convection in Earth’s mantle and in the oceans. The energy in these convection cycles flows continuously, as the system drives itself.</td>
</tr>
<tr>
<td><strong>Structure and Function:</strong> The way an object is shaped or structured determines many of its properties and functions.</td>
<td>In the lesson <strong>Conduction</strong>, students learn about conductors and insulators, which are built specifically out of material whose structure either allows the flow of thermal energy or prevents it depending on its use.</td>
</tr>
<tr>
<td>Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</td>
<td>In the lesson Lab: Thermal Heat Transfer, students experiment with the mass of materials to observe that two different masses of the same material will absorb thermal energy at different rates.</td>
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</tbody>
</table>
## Unit 9: Waves, Sound, and Light

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Patterns:</strong> Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>In the lesson <em>Properties of Light</em>, students observe the refraction of light through a prism. This is a phenomenon that is observed in nature when rainbows are formed due to the refraction of light through raindrops, and creates a visible, consistent pattern of colors.</td>
</tr>
<tr>
<td><strong>Cause and Effect:</strong> Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>In the lesson <em>Properties of Sound</em>, students observe that combining two sounds produces a sound with either a higher or lower amplitude. If the frequencies of the two sounds match, the amplitude will be higher. If the frequencies of the sounds are mismatched, the amplitude will shrink.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity:</strong> In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>In the lesson <em>Using Light</em>, students learn about lasers and how they release light due to the increased vibration of atoms. If enough energy is put into the system, the laser will release it as a beam of focused energy that can even cut materials including metals, ceramic, and plastics.</td>
</tr>
<tr>
<td><strong>Systems and System Models:</strong> A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>In the lesson <em>Wave Interactions</em>, students explore how waves interact with matter. Waves can be transmitted, absorbed, reflected, refracted, and diffracted, and understanding the systematic behavior of waves can allow students to make predictions of future behavior.</td>
</tr>
<tr>
<td><strong>Energy and Matter: Flows, Cycles, and Conservation:</strong> Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>In the lesson <em>Using Sound</em>, students learn about echoes and how the reflection of sound waves is used by both animals and humans. The reflection of sound waves can allow animals to orient themselves and find food, and assists humans in the medical and industry fields to create medical treatments and useful products.</td>
</tr>
<tr>
<td><strong>Structure and Function:</strong> The way an object is shaped or structured determines many of its properties and functions.</td>
<td>In the lessons <em>Introduction to Waves</em> and <em>Properties of Waves</em>, students observe the structure of a wave and identify wave features, such as crest, trough, wavelength, and amplitude.</td>
</tr>
<tr>
<td><strong>Stability and Change:</strong> For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</td>
<td>In the lesson <em>Sound Waves</em>, students study how sound waves change their speed depending on the medium the wave propagates through and the temperature of the medium. For example, sound will travel faster through water than through air, and even faster through a solid. It will also travel faster through a warmer substance than a cooler substance.</td>
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### UNIT 10: ELECTRICITY AND MAGNETISM

<table>
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<tbody>
<tr>
<td><strong>Patterns:</strong> Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.</td>
<td>In the lesson <strong>Electromagnetism</strong>, students observe how electricity and magnetism interact with each other, and how patterns in their behavior led to the discovery of electromagnetism. Students investigate this relationship more fully by studying solenoids, electromagnets, and electromagnet induction.</td>
</tr>
<tr>
<td><strong>Cause and Effect:</strong> Mechanism and Prediction: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</td>
<td>In the lesson <strong>Electric Charge</strong>, students investigate charging neutral substances using friction, conduction, or induction. If two objects are rubbed together using friction, they can become charged. If a charged object touches or is placed near a neutral object, it can also become charged.</td>
</tr>
<tr>
<td><strong>Scale, Proportion, and Quantity:</strong> In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</td>
<td>In the lesson <strong>Electromagnetism</strong>, students observe that a solenoid is composed of coils of wire that produce magnetism when an electric current moves through it. The greater the quantity of coils in the solenoid, or the stronger the electric current, the more powerful the solenoid’s generated magnetic force will be.</td>
</tr>
<tr>
<td><strong>Systems and System Models:</strong> A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</td>
<td>In the lesson <strong>Electric Circuits</strong>, students observe a closed circuit, involving a power source, a switch, and a device. This system is illustrated by a circuit diagram, which uses symbols to represent the parts of the circuit.</td>
</tr>
<tr>
<td><strong>Energy and Matter: Flows, Cycles, and Conservation:</strong> Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.</td>
<td>In the lesson <strong>Electric Current</strong>, students investigate how charge flows in an electric current. For example, an increase in potential difference between two materials will result in faster flow.</td>
</tr>
<tr>
<td><strong>Structure and Function:</strong> The way an object is shaped or structured determines many of its properties and functions.</td>
<td>In the lesson <strong>Magnets and Magnetism</strong>, students investigate a bar magnet, which is composed of a north pole and a south pole. The field of the north pole always flows to the south pole, and in this way north and south poles attract each other. Students learn that if two like-sided poles are brought together, they will always repel each other.</td>
</tr>
<tr>
<td><strong>Stability and Change:</strong> For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.</td>
<td>In the lesson <strong>Electric Current</strong>, students learn that the resistance of a material to an electric current decreases the rate of the flow of electrons. The more a conduit is insulated and resists an electric current, such as by becoming thinner or longer, the less the rate of flow.</td>
</tr>
</tbody>
</table>