

Grade 7 Science, Unit 2

Interactions of Matter

Overview

Unit abstract

Upon the completion of this unit of study, students will be able to provide molecular-level accounts of states of matter and changes between states, of how chemical reactions involve regrouping of atoms to form new substances, and of how atoms rearrange during chemical reactions. Students are also able to apply an understanding of optimization design and process in engineering to chemical reaction systems. Students are expected to demonstrate proficiency in obtaining, evaluating, and communicating information and developing and using models. The crosscutting concepts of structure and function; cause and effect; interdependence of science, engineering, and technology; and influence of science, engineering, and technology on society and on the natural world are organizing concepts for these disciplinary core ideas.

Essential questions

- How can particles combine to produce a substance with different properties?
- How does thermal energy affect particles?
- What happens when new materials are formed? What stays the same and what changes?
- How do atomic and molecular interactions explain the properties of matter we see and feel?

Written Curriculum

Next Generation Science Standards

MS. Structure and Properties of Matter		
Students who demonstrate understanding can:		
MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. [Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.] [Assessment Boundary: Assessment is limited to qualitative information.]		
The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
<p style="text-align: center;">Science and Engineering Practices</p> <p>Obtaining, Evaluating, and Communicating Information</p> <p>Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluating the merit and validity of ideas and methods.</p> <ul style="list-style-type: none"> Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence. (MS-PS1-3) 	<p style="text-align: center;">Disciplinary Core Ideas</p> <p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3) <i>(Note: This Disciplinary Core Idea is also addressed by MS-PS1-2.)</i> <p>PS1.B: Chemical Reactions</p> <ul style="list-style-type: none"> Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-3) <i>(Note: This Disciplinary Core Idea is also addressed by MS-PS1-2 and MS-PS1-5.)</i> 	<p style="text-align: center;">Crosscutting Concepts</p> <p>Structure and Function</p> <ul style="list-style-type: none"> Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3) <p style="text-align: center;">-----</p> <p style="text-align: center;">Connections to Engineering, Technology, and Applications of Science</p> <p>Interdependence of Science, Engineering, and Technology</p> <ul style="list-style-type: none"> Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (MS-PS1-3) <p>Influence of Science, Engineering and Technology on Society and the Natural World</p> <ul style="list-style-type: none"> The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-PS1-3)
<i>Connections to other DCIs in this grade-band:</i> MS.LS2.A (MS-PS1-3); MS.LS4.D (MS-PS1-3); MS.ESS3.A (MS-PS1-3); MS.ESS3.C (MS-PS1-3)		
<i>Articulation across grade-bands:</i> HS.PS1.A (MS-PS1-3); HS.LS2.A (MS-PS1-3); HS.LS4.D (MS-PS1-3); HS.ESS3.A (MS-PS1-3)		
Common Core State Standards connections: ELA/Literacy		
RST.6-8.1	Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions (MS-PS1-3)	
WHST.6-8.8	Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation. (MS-PS1-3)	

MS. Structure and Properties of Matter		
Students who demonstrate understanding can:		
MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. [Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.]		
The performance expectations above were developed using the following elements from the NRC document <i>A Framework for K-12 Science Education</i> :		
<p style="text-align: center;">Science and Engineering Practices</p> <p>Developing and Using Models</p> <p>Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.</p> <ul style="list-style-type: none"> Develop a model to predict and/or describe phenomena. (MS-PS1-4) 	<p style="text-align: center;">Disciplinary Core Ideas</p> <p>PS1.A: Structure and Properties of Matter</p> <ul style="list-style-type: none"> Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4) In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations. (MS-PS1-4) The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4) <p>PS3.A: Definitions of Energy</p> <ul style="list-style-type: none"> The term “heat” as used in everyday language refers both to thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy from one object to another. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (<i>secondary to MS-PS1-4</i>) The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system’s material). The details of that relationship depend on the type of atom or molecule and the interactions among the atoms in the material. Temperature is not a direct measure of a system’s total thermal energy. The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material. (<i>secondary to MS-PS1-4</i>) 	<p style="text-align: center;">Crosscutting Concepts</p> <p>Cause and Effect</p> <ul style="list-style-type: none"> Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)
<i>Connections to other DCIs in this grade-band:</i> MS.ESS2.C (MS-PS1-4)		
<i>Articulation across grade-bands:</i> HS.PS1.A (MS-PS1-4); HS. PS1.B (MS-PS1-4); HS.PS3.A (MS-PS1-4)		
Common Core State Standards connections: ELA/Literacy		
RST.6-8.7	Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (<i>MS-PS1-4</i>)	
Common Core State Standards connections to Mathematics		
6.NS.C.5	Understand that positive and negative numbers are used together to describe quantities having opposite directions or values (e.g., temperature above/below zero, elevation above/below sea level, credits/debits, positive/negative electric charge); use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation. (MS-PS1-4)	

Clarifying the standards

Prior learning

All concepts are newly introduced at middle school.

Progression of current learning

Driving question 1

How can student-developed models predict and describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed?

Concepts

- Changes in particle motion, temperature, and state of a pure substance occur when thermal energy is added or removed.
- Qualitative molecular-level models of solids, liquids, and gases can be used to show that adding or removing thermal energy increases or decreases the kinetic energy of the particles until a change of state occurs.
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.
- In a liquid, the molecules are constantly in contact with others.
- In a gas, the molecules are widely spaced except when they happen to collide.
- In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.
- The changes of state that occur with variations in temperature or pressure can be described and predicted using models of matter.
- The term heat as used in everyday language refers both to thermal energy and the transfer of that thermal energy from one object to another.
- Thermal energy is the motion of atoms or molecules within a substance.
- In science, heat is used to refer to the energy transferred due to the temperature difference between two objects.

Practices

- Develop a model that predicts and describes changes in particle motion that could include molecules or inert atoms or pure substances.
- Use cause-and-effect relationships to predict changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural or designed systems.

- The temperature of a system is proportional to the average internal kinetic energy and potential energy per atom or molecule (whichever is the appropriate building block for the system's material).
- The details of the relationship between the average internal kinetic energy and the potential energy per atom or molecule depend on the type of atom or molecule and the interactions among the atoms in the material.
- Temperature is not a direct measure of a system's total thermal energy.
- The total thermal energy (sometimes called the total internal energy) of a system depends jointly on the temperature, the total number of atoms in the system, and the state of the material.
- Cause-and-effect relationships may be used to predict and describe changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed in natural systems.

Driving question 2

How can information be gathered and evaluated to show that synthetic materials come from natural resources and affect society?

Concepts

- Each pure substance has characteristic physical and chemical properties that can be used to identify it.
- Substances react chemically in characteristic ways.
- In a chemical process, the atoms that make up the original substances are regrouped into different molecules.
- New substances that result from chemical processes have different properties from those of the reactants.
- Natural resources can undergo a chemical process to form synthetic material.
- Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.

Practices

- Obtain, evaluate, and communicate information to show that synthetic materials come from natural resources and affect society.
- Gather, read, and synthesize information about how synthetic materials formed from natural resources affect society.
- Assess the credibility, accuracy, and possible bias of each publication and methods used within the publication.
- Describe how information about how synthetic materials formed from natural resources affect society is supported or not supported by evidence.

- Engineering advances have led to discoveries of important synthetic materials, and scientific discoveries have led to the development of entire industries and engineered systems using these materials.
- Technology use varies from region to region and over time.
- The uses of technologies (engineered/synthetic materials) and any limitations on their use are driven by individual or societal needs, desires, and values.
- The uses of technologies (engineered/synthetic materials) and any limitations on their use are driven by the findings of scientific research and by differences in such factors as climate, natural resources, and economic conditions.

Integration of content, practices, and crosscutting concepts

Students will locate information that describes changes in particle motion, changes in temperature, or changes in state as thermal energy is added to or removed from a pure substance. Students will then use models to predict and describe the changes in particle motion, temperature, and state of a pure substance. An example could include the change of state of water from its solid (ice) to liquid and vapor with the addition of thermal energy. Students will come to understand that this process is reversible through the removal of thermal energy, where the pure substance can return from a vapor to a liquid and back to a solid state.

Students who accurately demonstrate understanding will be able to develop qualitative molecular-level models of solids, liquids, and gases to show the cause-and-effect relationships of adding or removing thermal energy, which increases or decreases the kinetic energy of the particles until a change of state occurs. Models could include drawings and diagrams.

Students will also need to use mathematics to demonstrate their understanding of the particle motion that is taking place during these changes in state. They will use positive and negative numbers to represent the changes in particle motion and temperature as thermal energy is added or removed. They will then integrate an expression of that same quantitative information in a visual format.

It is important to note that students will need to be responsible for developing the models that they use. It is possible that the teacher could model the process with one type of model and provide opportunities for students to use different types of model to illustrate the same process.

After students have a firm understanding of the motion of particles during a phase change, they will be able to move to the next section of this unit. In this portion of the unit of study, students will apply their understanding of particle and chemical change from Unit 1 to make sense of how natural resources react chemically to produce new substances. Students will explain that as a result of the rearrangement of atoms during a chemical process, the synthetic substance has different characteristic properties than the original pure substance. For example, pure substances like methane, carbon monoxide, and carbon dioxide can be combined chemically to form synthetic fuel. The synthetic fuel would have different characteristic properties than the original pure substances.

Within this unit, students will gather, read, and synthesize qualitative information from multiple sources about the use of natural resources to form synthetic materials and how these new materials affect society. Examples of new materials could include new medicine, foods, and alternative fuels. Some sources could include journals,

Bristol–Warren, Central Falls, Cranston, Segue Institute for Learning, Tiverton, and Woonsocket, with process support from The Charles A. Dana Center at the University of Texas at Austin

articles, brochures, or digital media from government publications and/or private industries. Students will cite some of these sources to support the analysis of evidence that these synthetic materials were formed from natural resources and have an impact on society. They will pay special attention to the precise details of explanations or descriptions of how these new substances affect society. Students will also include relevant information from multiple print and digital sources about these impacts. While gathering this information, they will use search terms effectively, assess the credibility and accuracy of each source, and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Integration of DCI from prior units within this grade level

The content from PS1.A: Structure and Properties of Matter and PS1.B: Chemical Reactions was introduced in Unit 1. Content within this unit will build on this prior learning.

Integration of mathematics and/or English Language Arts/literacy

Mathematics

Integrate quantitative information about changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed that is expressed in words with a version of that information that is expressed visually.

Understand that positive and negative numbers are used together to describe quantities having opposite directions or values. Use positive and negative numbers to represent changes in particle motion and temperature when thermal energy is added or removed, explaining the meaning of zero in each situation.

English language arts/literacy

Cite specific text to support the analysis of evidence that synthetic materials formed from natural resources affect society. Attend to the precise details of explanations or descriptions.

Gather relevant information from multiple print and digital sources about the impact on society of synthetic materials that are formed from natural resources. Use search terms effectively, assess the credibility and accuracy of each source, and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.

Future learning

Physical science

- Each atom has a charged substructure consisting of a nucleus made of protons and neutrons surrounded by electrons.
- The periodic table orders elements horizontally by the number of protons in nucleus of the element's atoms and arranges elements with similar chemical properties vertically in columns. The repeating patterns of this table reflect patterns of outer electron states.
- Electrical forces within and between atoms determine the structure and interactions of matter at the bulk scale.
- A stable molecule has less energy than the same set of atoms separated; at least this energy must be provided in order to take the molecule apart.
- Chemical processes, their rates, and whether or not they store or release energy can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with

consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy.

- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present.
- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
- Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved even as, within the system, energy is continually transferred from one object to another and between its various possible forms.
- At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position) of the particles.
- In some cases the relative position of energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.

Life science

- Ecosystems have carrying capacities, which are limits to the numbers of organisms and populations they can support. These limits result from such factors as the availability of living and nonliving resources and from such challenges such as predation, competition, and disease. Organisms would have the capacity to produce populations of great size were it not for the fact that environments and resources are finite. This fundamental tension affects the abundance (number of individuals) of species in any given ecosystem.
- Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction).
- Humans depend on the living world for resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value.
- Resource availability has guided the development of human society.
- All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.

Number of Instructional Days

Recommended number of instructional days: 18 (1 day = approximately 50 minutes)

Note—The recommended number of days is an estimate based on the information available at this time. Teachers are strongly encouraged to review the entire unit of study carefully and collaboratively to determine whether adjustments to this estimate need to be made.

