Grade 7 Science, Quarter 1, Unit 1.1

Properties of Matter

Overview

Number of instructional days: 15 (1 day = 50 minutes)

Content to be learned

- Identify different substances using data about characteristic properties of matter including melting and boiling point and solubility.
- Compare and classify different substances using data about characteristic properties of matter.
- Classify and compare substances as solids, liquids, or gases using characteristic properties.
- Classify and compare substances as metal or non-metals using characteristic properties.
- Use diagrams and models to show the difference between atoms and molecules not including the structure of atoms.
- Use diagrams or models to classify matter as atoms, molecules.
- Explain that, when a substance undergoes physical changes, the physical appearance may change but the chemical make-up and its chemical properties do not.

Science processes to be integrated

- Identify and compare characteristic properties of matter.
- Use characteristic properties to classify matter.
- Use models and diagrams to classify matter.
- Use and analyze models.
- Make scientific explanations.

Essential questions

- What would be the difference between models of an atom and molecule?
- What are some characteristic properties of matter that can be used for classification and how do they compare to each other?
- What are the characteristic properties of solids, liquids, and gases?
- What is the difference between the characteristic properties of metals and those of nonmetals?
- How does a chemical change compare to a physical change?

Written Curriculum

Grade-Span Expectations

PS1 - All living and nonliving things are composed of matter having characteristic properties that distinguish one substance from another (independent of size or amount of substance).

PS1 (5-8) INQ+POC –2

Given data about characteristic properties of matter (e.g., melting and boiling points, density, solubility) identify, compare, or classify different substances.

PS1 (7-8) –2 Students demonstrate an understanding of characteristic properties of matter by …

2b classifying and comparing substances using characteristic properties (e.g., solid, liquid, gas; metal, non-metal).

PS1 (5-8) MAS –5

Given graphic or written information, classify matter as atom/molecule or element/compound (Not the structure of an atom).

PS1 (7-8) – 5 Students demonstrate an understanding of the structure of matter by …

5a using models or diagrams to show the difference between atoms and molecules.

5e explaining that when substances undergo physical changes, the appearance may change but the chemical makeup and chemical properties do not.

Clarifying the Standards

Prior Learning

In grades K–2, students identified, described, and compared properties of solids and liquids. They also made logical predictions about changes in the state of matter when adding or taking away heat. Students demonstrated an understanding of characteristic properties of matter by identifying, comparing, and sorting objects by similar or different physical properties like size, shape, color, texture, smell and weight. Students also recorded observations and data about physical properties and used attributes of properties to state why objects are grouped together.

In grades 3–4, students continued to identify, describe, and compare the properties of solids and liquids, but also added gases. Students observed and described basic physical changes and used evidence to support why objects were or were not grouped together. Students demonstrated an understanding of characteristic properties of matter by continuing to identify, compare, and sort objects by similar or different physical properties. Students examined the same properties as in grades K–2 and added temperature and flexibility. Students extended on their prior learning by citing evidence to support conclusions about why objects are or are not grouped together. Students demonstrated an understanding of physical changes like freezing, thawing, or tearing.

In grades 5–6, students recognized that different substances have properties that allow them to be identified regardless of the size of the sample. They also extended on prior learning by classifying and comparing substances using characteristic properties. Students also explained that regardless of how parts of an object are arranged, the mass of the whole is always the same as the sum of the masses of its parts. They also demonstrated an understanding of characteristic properties by comparing the masses of objects of equal volume made of different substances.

Current Learning

Instruction around atoms and molecules should be at the developmental level because students have not been exposed to content about atoms and molecules prior to this unit. It is important to remember that students are distinguishing between atoms and molecules, but are not examining the subatomic structure of atoms. Instruction about the characteristic properties of metals and nonmetals is being taught at the developmental level. Students will be introduced to chemical changes and chemical properties of matter. Students have had previous instruction about the properties of matter and physical changes, therefore this instruction should begin at the level of reinforcement.

While learning this information, students could begin with content that is familiar to them by reviewing and reinforcing what they know about the properties of matter. In this unit, students are focusing on characteristic properties of matter including properties that they have not studied before: melting points, boiling points, and solubility. Students examine the characteristic properties of solids, liquids, gases, metals, and nonmetals. This instruction should be at a developmental level. This content should be taught in a way that will make it possible for students to examine patterns of change. For example, patterns that exist among metals that are different from patterns that exist among nonmetals (i.e., with the exception of mercury, metals are solid at room temperature, and most metals are malleable, while nonmetals are poor conductors of electricity). Students apply this knowledge to classify and compare metals and nonmetals.

Students continue to develop their understanding of the structure of matter. This instruction started in the early grades, however distinguishing between atoms and molecules is new and should be taught at the developmental level. Students will not be distinguishing between elements and compounds until grade 8.

Learning about chemical changes is new to students and needs to be taught at the developmental level of instruction. They are learning how chemical changes in matter are different from a physical change in matter.

Using the periodic table, students can visualize the grouping of metals and nonmetals based on their characteristic properties. Students can use the periodic table to help them determine how the physical properties of metals are different from the physical properties of nonmetals. In order to meet the requirements of inquiry, it is important that students are not told the differences. Instead, they need to use the periodic table as a data source to ask and answer questions. In addition, students can also examine physical examples of metals and nonmetals to determine if the information that they collect matches actual samples of matter from both groups of substances.

In order to meet the requirements of the standards, scientific processes must be embedded in this instruction. When learning about atoms and molecules, students need to use models that make it possible for them to visualize the differences between these levels of organization of matter. Models may be physical or conceptual. Students must understand that, when a substance changes chemically, while the atoms that make up the substance are arranged differently, all of the atoms are still present.

After students have an understanding of atoms and molecules, they can then examine physical and chemical changes to determine how the properties of the substance respond to change. Students have

already studied physical changes; therefore this knowledge can be applied to their new learning about chemical changes. Because students are not introduced to chemical symbols and formulas until grade 8, it is important to use word equations and actual demonstrations of chemical changes to help students understand this content. The key understanding that students must have is that physical changes can take place without changing its composition. The atoms and molecules that are found in a substance are the same substances that will be found after a physical change. A chemical change will change the composition of matter and therefore will change the characteristic properties of the matter.

Future Learning

In grade 8, students will continue to demonstrate an understanding of characteristic properties of matter by measuring the mass and volume of both regular and irregular objects and use those values as well as the relationship $D=m/v$ to calculate density. Students will also classify common elements and compounds using symbols and chemical formulas. They will be introduced to the characteristic property of density. In high school, students will interpret symbols and formulas of chemical equations beginning with simple examples. They will use symbols and chemical formulas to show the chemical rearrangements that produce a new substance in a chemical change and will identify new substances that result from chemical change. Students will learn that, when new substances are formed due to chemical change, the properties of the new substance may be very different from the original substances. Students will use the periodic table on multiple occasions to identify elements, pure substances, and complex compounds. In high school, students will continue to demonstrate an understanding of characteristic properties of matter by utilizing appropriate data related to chemical and physical properties, to distinguish one substance from another or identify an unknown substance. Students also use data and advances in technology to explain how the understanding of atomic structure has changed over time and identify and explain the basis for the arrangement of the elements within the periodic table. Students will also predict the relative physical and chemical properties of an element based on its location within the periodic table.

Additional Findings

Students in early grades maintain a continuous (non-particulate) view of chemical substances and need to understand that each element or compound can be represented as a structure or pattern of component units—atoms or molecules (*Making Sense of Secondary Science*, p. 96). Going into detail on the structure of the atom is unnecessary (*Benchmarks for Science Literacy,* p. 77).

Some common misconceptions at the seventh grade level are that matter just disappears—for example, when petrol is used as a fuel "it just vanishes." When students were probed to explain about chemical changes, they had no conception other than "it just happens like that" (*Making Sense*, p. 86) Several studies have found that children often use the term "chemical change' to encompass changes in physical state and other physical transformations, particularly when the color of a substance alters (*Making Sense*, p. 85). Students commonly fail to understand that weight and volume are conserved in objects that change shape or state of matter (*Atlas of Science Literacy*, p. 56).

The scientific understanding of atoms and molecules requires combining two closely related ideas: All substances are composed of invisible particles, and all substances are made up of a limited number of basic ingredients, or "elements." These ideas merge into the idea that differently combining particles of basic ingredients leads to millions of materials with different properties (*Benchmarks for Science Literacy,* p. 75). Distinguish between chemical and physical changes for students. How well students make the distinction between those two terms depends partly upon their conception of the term "substance." For instance, if they regard ice as a different substance from water, then they are likely to classify the melting of ice as a chemical change (*Making Sense*, p. 85).

Grade 7 Science, Quarter 1, Unit 1.2

Energy

Overview

Number of instructional days: 7 (1 day = 50 minutes)

Content to be learned

- Understand that energy is necessary for change to occur in matter.
- Describe the motion of molecules for a material in warmer and cooler states.
- Explain the difference among conduction, convection, and radiation.
- Create a diagram to explain how heat energy travels in different directions and through different materials by conduction, convection, and radiation.

Science processes to be integrated

- Design diagrams, models, and analogies.
- Examine cause and effect relationships.
- Make scientific comparisons.
- Identify patterns of change.
- Describe energy changes within a system.

Essential questions

- How is the heat transfer by conduction different from heat transfer by radiation?
- How is the motion of molecules in cool substances different from the motion of molecules in warmer substances?
- How is the movement of heat by convection different from heat transfer by conduction or radiation?
- What patterns of motion can be observed as heat travels from a heating element through a pot of boiling water and to the air near the heating element?

Written Curriculum

Grade-Span Expectations

PS 2 - Energy is necessary for change to occur in matter. Energy can be stored, transferred, and transformed, but cannot be destroyed.

PS2 (5-8) INQ+SAE+POC – 7

Use data to draw conclusions about how heat can be transferred (convection, conduction, radiation).

PS2 (7-8)-7 Students demonstrate an understanding of heat energy by …

7a designing a diagram, model, or analogy to show or describe the motion of molecules for a material in a warmer and cooler state.

7b explaining the difference among conduction, convection, and radiation and creating a diagram to explain how heat energy travels in different and through different materials by each of these methods.

Clarifying the Standards

Prior Learning

Students in grades K–2 learned that the sun is a source of heat. They learned through experimentation observation and prediction that objects may change in temperature by adding and subtracting heat. Students also identified the sun as a source of energy and described observable effects of light using a variety of light sources.

Students in grades 3–4 described or demonstrated how heat can be produced in many ways. They used data to classify a variety of materials as conductors or insulators and predicted the observable effects of energy. Students described that heat can be produced in many and that heat moves from warm objects to cold objects until both objects are the same temperature. Students demonstrated an understanding that heat moves from one object to another causing a temperature change. Students have been introduced to light energy by investigated observable effects of light using a variety of light sources and have predicted, described, and investigated how light rays are reflected, refracted, or absorbed. Students also demonstrated an understanding of energy by experimenting to identify and classify different pitches and volumes of sound produced by different objects.

Students in grades 5-6 differentiated among the different forms of energy and explained how energy may be stored. They used data to draw conclusions about how heat can be transferred. This was done by using real world applications where heat energy is transferred showing the direction that heat energy flows. Students also identified real world applications where heat energy is transferred and showed the direction that the heat energy flows. Students have differentiated among the properties of various forms of energy, explained how energy may be stored in various ways, and described sound as the transfer energy through various materials.

Current Learning

Instruction should be at the developmental level when teaching the motion of molecules. Students will need to learn that all matter is made up of particles that are constantly in motion and that there is a direct relationship between the amounts of motion found in matter and the amount of heat that is being transferred. Students need to be able to make diagrams that show that heat transfer is always in the direction from warmer to cooler and that this transfer is a result of molecular motion. Transitioning from the unit on Properties of Matter, it is important to begin with the concept of energy and how it is needed to cause a change in matter. Determining differences between heat energy, thermal energy, and temperature is critical at this point to avoid common student misconceptions.

Students will need to explain the differences between conduction, convection, and radiation and how heat travels through different materials through each of those methods.

For example, heat causes molecules to move or vibrate faster. In conduction, the warm molecules come into contact with cooler molecules transferring heat energy. This transfer of energy can be observed as an increase in temperature. Students can be asked to observe evidence of heat transfer by conduction and radiation by using a heat source to warm a row of chocolate chips that have been spaced along a metal strip. If the metal strip is placed slightly above the heat source, being careful not to allow the metal strip to touch the heat source, students will be able to observe a pattern of heat transfer as the heat is transferred down the row of chips causing the chips to melt starting closest to the heat source and then progressing along the row of chips. After an observation of this type of heat transfer, students could then be required to explain how the heat is transferred through radiation and conduction. Similar activities can be used to make it possible for students to observe convection and follow up their observations with scientific explanations.

Future Learning

In eighth grade, students will use real-world examples to explain the transfer of kinetic to potential energy. They will explain that while energy may be stored, transferred, or transformed the total amount of energy will be conserved. Also in eighth grade, students will learn about phase changes and molecular movement. In high school, students will go more in depth into explaining the law of conservation of energy and how it relates to the efficiency of a system. In high school, students will describe and diagram energy transformations that occur in different systems. They will also explain the Law of Conservation of Energy as it related to the efficiency of a system. Students will also identify a given chemical reaction or a biological process as endothermic or exothermic based on the information provided.

Additional Findings

Students at this level need to know that heat energy, thermal energy, and temperature are not the same. Common misconceptions around the topic of energy include that it is only associated with animate objects, that it is a causal agent stored in certain objects, that it is linked with force and movement, that energy is fuel, or that energy is a fluid, ingredient, or product. Students related energy to fitness and strength, saying that "without energy, living things were tired and less active." Students tend to think energy is something needed to make things go or run, and they have difficulty distinguishing energy needs. Important ideas about energy include that all physical events involve transferring energy or changing one form of energy into another and that whenever energy is reduced in one place, it is increased somewhere else by exactly the same amount. Some of it is likely to transform into heat, which spreads around and therefore is not available for use. Many students mistakenly think that cold spreads like heat (*Benchmarks for Science Literacy,* pp. 81, 84, 143).

Middle-school students often believe liquids and gases are not matter, or that these forms of matter are weightless. It is difficult for students of all ages to appreciate the very small size of particles as well as the intrinsic motion of particles within solids, liquids, and gasses. The relation of heat energy to the disorderly motion of molecules contributes to the constant motion of molecules and a molecular explanation of changes of state (*Atlas of Science Literacy* p. 54, 58).

Middle-school students often attribute properties such has hotness and coldness to particles. Often there is belief that heat is produced due to the particles rubbing against each other (NSTA.org).

Grade 7 Science, Quarter 1, Unit 1.3

Forces and Motion

Overview

Number of instructional days: 20 (1 day = 50 minutes)

Content to be learned

- Determine or predict the net effect of multiple forces on position, speed, and direction of motion of objects using data.
- Measure distance and time of a moving object.
- Use measured values to calculate speed of an object using $s = d/t$.
- Differentiate among speed, velocity, and acceleration.
- Differentiate between balanced and unbalanced forces.
- Predict and test the effect of unbalanced forces on the speed or direction of motion on an object.

Science processes to be integrated

- Given examples make predictions based on data.
- Use tools to measure variables.
- Use formulas to calculate.
- Explain and give/show examples to differentiate system parts.
- Collect and use experimental data to draw conclusions.

Essential questions

- How does changing the amount of time an object takes to move a certain distance affect the speed of that object?
- How do you know an object is accelerating?
- What is the net effect on the speed or direction or both of an object when acted upon by unbalanced forces?
- What are the similarities and differences between speed, acceleration, and velocity?

Written Curriculum

Grade-Span Expectations

PS 3 - The motion of an object is affected by forces.

PS3 (5-8) INQ+ POC –8

Use data to determine or predict the overall (net effect of multiple forces (e.g., friction, gravitational, magnetic) on the position, speed, and direction of motion of objects.

PS3 (7-8) – 8 Students demonstrate an understanding of motion by…

8a measuring distance and time for a moving object and using those values as well as the relationship s=d/t to calculate speed ~~and graphically represent the data~~.

8c differentiating among speed, velocity and acceleration.

8d making and testing predictions on how unbalanced forces acting on objects change speed or direction of motion, or both.

PS3 (5-8) SAE+INQ – Local Assessment Only

Experiment, observe, or predict how energy might be transferred by means of waves.

PS3 (7-8) – LA Students demonstrate an understanding of the visible spectrum of light by…

LAa experiment how light from the sun is made up of a mixture of many different colors of light (e.g. using prisms, spectrometers, crystals).

LAb representing in words, diagrams, or other models the visible spectrum as a part of the electromagnetic spectrum (consisting of visible light, infrared, and ultraviolet radiation) and composed of all colors of light.

Clarifying the Standards

Prior Learning

In grades K–2, students showed how pushing and pulling does or does not move an object and also predicted the direction that an object will or will not move if a force is applied to it. Students also showed that different objects fall to earth unless something is holding it up.

In grades 3–4, students described a change in position relative to other objects or backgrounds. Students investigated and described that different amounts of force can change the direction or speed of an object in motion. They also extended their learning from K–2 by conducting experiments to demonstrate that different objects fall to earth unless something is holding them up.

In grades 5–6, students used data or graphs to compare the relative speed of objects. Students also added to previous learning about pushing and pulling by recognizing that a force is a push or pull. Students then explained that forces cause changes in speed or direction of motion.

Current Learning

Students have learned about speed in previous grades, however the use of the formula $s=d/t$ is new to students and instruction about this formula need to begin at a developmental level. The concepts of velocity and acceleration are also new to students and instruction should be at the developmental level. Students are introduced to the terms *unbalanced* and *balanced* forces for the first time. Students predict the effect of unbalanced forces on the movement of an object. They test and collect data to show the effect of unbalanced forces on the movement of an object. When studying about unbalanced forces, students perform investigations that make it possible for them to make their own predictions and then test those predictions. It is important that students ask the questions, make the predictions, and test their predictions.

In this unit of study, students use the formula $s=d/t$ to study the relationship between distance and time in relation to speed. Students may need guidance or instruction using metric tools and the metric system. Students measure distance and time of moving objects and calculate speed using the formula. Students explain and give/show examples to differentiate between speed, velocity, and acceleration. In order to meet the requirement of the standards, inquiry and the identification of patterns of change must be embedded into student learning. When students are using the formula $s=d/t$, students must not only be able to calculate the speed of an object, but also identify patterns and trends in data. Some examples include being able to predict what happens to speed if distance remains the same but time decreases or increases. Students collect and use experimental data to draw conclusions. Students learn the difference between speed, velocity, and acceleration, through problem solving and scientific inquiry.

Future Learning

In grade 8, students will graphically represent speed and acceleration based on data. They will solve for any variable when using the formula $s = d/t$. They will learn that the acceleration of an object is proportional to the force on the object and inversely proportional to the mass of the object. They will also differentiate between mass and weight.

In grades 9–11, students will use different reference planes to predict and/or graph the path of an object when explaining how and why that motion occurs. They will also explain how distance and velocity change over time for free-falling objects.

Additional Findings

Students in grades 5–8 associate force with motion and have difficulty understanding balanced forces in equilibrium. Students easily understand that the book is pushing down on the desk, but have difficulty understanding that the desk is pushing up on the book when forces are balanced (*National Science Education Standards* p. 154).

Students have no trouble believing that an object at rest stays that way unless acted on by a force, but have difficulty with the idea that an object in motion will stay in motion unless acted on by a force (*Benchmarks for Science Literacy,* p. 90).

Learners tend to think of a force as a property of a single object, rather than as a feature of interaction between two objects. The earlier the connections are made in proportional reasoning (speed being proportional to acceleration), the stronger the foundation for understanding in differentiation between the terms. Students have difficulty associating a “kick” or a “throw” with a “push” (*Making Sense of Secondary Science*, p. 149, 150, 155).