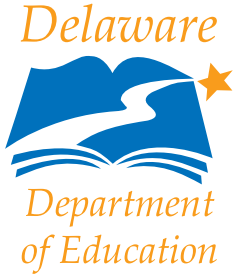

Science Standard 2
Materials and Their Properties
Grade Level Expectations

Science Standard 2
Materials and Their Properties

Materials exist throughout our physical world. The structures of materials influence their physical properties, chemical reactivity and use.

Strand	Grades K-3	Grades 4-5	Grades 6-8	Grades 9-12
Properties and Structure of Materials Enduring Understanding: The structures of materials determine their properties. Essential Question: How do the properties of materials determine their use? (Grades K-8) Essential Question: How do the properties and structures of materials determine their uses? (Grades 9-12)	1. Materials can be described and classified according to the following physical properties: size, shape, mass, texture, color, and material composition. Students can observe materials' physical properties by using tools that include rulers, balances, thermometers and hand lenses. 2. Materials exist in one of three states – solid, liquid, or gas. Solids and liquids have easily observable properties and may change from one form to the other. 3. Physical properties of materials can be changed by exposure to water, heat, light, or by cutting, mixing, and grinding.	1. Observable physical properties can be used to classify materials. These physical properties may include solubility, mass, magnetism, and electrical conductivity. Tools such as graduated cylinders, balances, rulers, magnifiers, simple circuits, and magnets are used to study the physical properties. 2. Heating and cooling of materials may produce changes in the state of solids, liquids and gases.	1. All matter consists of particles too small to be seen with the naked eye. The arrangement, motion, and interaction of these particles determine the three states of matter (solid, liquid, and gas). Particles in all three states are in constant motion. In the solid state, tightly packed particles have a limited range of motion. In the liquid state, particles are loosely packed and move past each other. In the gaseous state, particles are free to move. 2. A phase change may occur when a material absorbs or releases heat energy. Changes in phase do not change the particles but do change how they are arranged. 3. Some physical properties, such as mass and volume, depend upon the amount of material. Other physical properties, such as density and melting point, are independent of the quantity of material. Density and melting point are unique physical properties for a material. Tools such as microscopes, scales, beakers, graduated cylinders, Celsius thermometers, and metric rulers are used to measure physical properties.	1. All matter is composed of minute particles called atoms. Most of the mass of an atom is concentrated in the nucleus. In the nucleus, there are neutrons with no electrical charge and positively charged protons. Negatively charged electrons surround the nucleus and overall, the atom is electrically neutral. 2. Elements and compounds are pure substances. Elements cannot be decomposed into simpler materials by chemical reactions. Elements can react to form compounds. Elements and/or compounds may also be physically combined to form mixtures. 3. Isotopes of a given element differ in the number of neutrons in the nucleus. Their chemical properties remain essentially the same. 4. The periodic table arranges the elements in order of atomic number (the number of protons). The elements are grouped according to similar chemical and physical properties. Properties vary in a regular pattern across the rows (periods) and down the columns (families or groups). *(continued on next page)*

Science Standard 2
Materials and Their Properties

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Strand	Grades K-3	Grades 4-5	Grades 6-8	Grades 9-12
Properties and Structure of Materials continued from previous page			4. An important property of materials is their ability to conduct heat. Some materials, such as certain metals, are excellent conductors of heat while other materials, such as glass, are poor conductors (good thermal insulators). 5. Exposure to energy, such as light and heat, may change the physical properties of materials.	As a result, an element's chemical and physical properties can be predicted knowing only its position on the periodic table. 5. An atom's electron structure determines its physical and chemical properties. Metals have valence electrons that can be modeled as a sea of electrons where the valence electrons move freely and are not associated with individual atoms. These freely moving electrons explain the metallic properties such as conductivity, malleability, and ductility. 6. Ionic compounds form when atoms transfer electrons. Covalent compounds form when atoms share electrons. Both types of interactions generally involve valence electrons and produce chemical bonds that determine the chemical property of the compound. 7. A change in physical properties does not change the chemical composition of the substance. The physical properties of elements and compounds (such as melting and boiling points) reflect the nature of the interactions among their atoms, ions, or molecules and the electrical forces that exist between.

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Strand	Grades K-3	Grades 4-5	Grades 6-8	Grades 9-12
Properties and Structure of Materials continued from previous page				8. A change of phase may occur when there is a change in the potential energy of the atoms or molecules of a substance. 9. Temperature, pressure, and volume are important properties of a gas. A change in two of these properties results in predictable changes in the third.
Mixtures and Solutions Enduring Understanding: The properties of a mixture are based on the properties of its components. Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures?		1. Most materials are physical mixtures. Physical mixtures can be composed of different kinds of materials, each having distinct physical properties. These physical property differences can be used to separate, sort, and group the materials of the mixture. 2. Mixtures can consist of different combinations of solids and/or liquids. The characteristics of these resulting mixtures depend on the relative amounts and properties of the components. 3. Physical properties can be used to separate mixtures through techniques such as filtration and evaporation. 4. When a solid is dissolved in a liquid, a solution is formed that can be separated through the process of evaporation.	1. Mixtures can be homogeneous or heterogeneous. Mixtures may be solids, liquids, and/or gases. Most materials are physical mixtures consisting of different components in varying concentrations. The individual components can be separated using the components' unique physical properties. 2. Solutions are homogenous mixtures of two or more components. The properties of a solution depend on the nature and concentration of the solute(s) and the nature of the solvent(s). 3. The rate of solubility is influenced by temperature and the surface area of the solute. 4. Temperature of the solvent can affect the saturation point of the solution.	1. Properties of solutions, such as pH, solubility, and electrical conductivity depend upon the concentration and interactions of the solute and solvents. 2. A variety of methods can be used to separate mixtures into their component parts based upon the chemical and physical properties of the individual components.

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Strand	Grades K-3	Grades 4-5	Grades 6-8	Grades 9-12
Mixtures and Solutions continued from previous page			5. In mixtures, individual components move from areas of higher concentration to areas of lower concentration to eliminate concentration differences. Diffusion is the movement of individual components.	
Conservation of Matter Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same. Essential Questions: How does conservation of mass apply to the interaction of materials in a closed system?		1. The mass of an object remains unchanged when broken into parts. The sum of the parts equals the whole.	1. The total mass of the mixture is equal to the sum of the masses of the components. Total mass is conserved when different substances are mixed.	1. The total mass of the system remains the same regardless of how atoms and molecules in a closed system interact with one another, or how they combine or break apart. 2. Radioactive isotopes are unstable and undergo spontaneous and predictable nuclear reactions emitting particles and/or radiation, and become new isotopes that can have very different properties. In these nuclear changes, the total of the mass and energy remains the same.
Chemical Reactions Enduring Understanding: There are several ways in which elements and/or compounds react to form new substances and each reaction involves energy. Essential Question: What determines the type and extent of a chemical reaction?				1. Chemical reactions result in new substances with properties that are different from those of the component parts (reactants). 2. There are different types of chemical reactions. Precipitation reactions produce insoluble substances (e.g., double replacement). *(continued on next page)*

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Strand	Grades K-3	Grades 4-5	Grades 6-8	Grades 9-12
Chemical Reactions continued from previous page				The transfer of electrons between atoms is a reduction-oxidation (redox) reaction (e.g., single-replacement combustion, synthesis, decomposition). Some acid/base reactions involve the transfer of hydrogen ions. 3. The rate of a chemical reaction depends on the properties and concentration of the reactants, temperature, and the presence or absence of a catalyst. 4. Energy is transformed in chemical reactions. Energy diagrams can illustrate this transformation. Exothermic reactions release energy. Endothermic reactions absorb energy. 5. A catalyst lowers the activation energy of a chemical reaction. The catalyst remains unchanged and is not consumed in the overall reaction. Enzymes are protein molecules that catalyze chemical reactions in living systems. 6. Certain small molecules (monomers) react with one another in repetitive fashion (polymerization) to form long chain macromolecules (polymers). *(continued on next page)*

Science Standard 2
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Strand	Grades K-3	Grades 4-5	Grades 6-8	Grades 9-12
Chemical Reactions continued from previous page				The properties of the macromolecules depend on the properties of the molecules used in their formation and on the lengths and structure of the polymer chain. Polymers can be natural or synthetic.
Material Technology Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment. Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?	1. The properties of materials influence their use. Some materials are more suitable for making a particular product or device. 2. Technology has created new materials that can help people solve problems.	1. Many materials can be recycled and used again (sometimes in different forms).	1. Synthetic materials and/or modified natural materials are produced to make products used in everyday life. 2. The production of new materials has social, environmental, and other implications that require analyses of the risks and benefits.	1. Materials' properties determine their use. New materials can improve the quality of life. However, their development and production often raise social, economic, and environmental issues that require analyses of the risks and benefits.

Standard 2: Materials and Their Properties, Grade Level Expectations Grades K-3

Essential Question: How do the properties of materials determine their use? Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?			
Enduring Understanding: The structures of materials determine their properties. Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.			
All students in **Kindergarten** will be able to:	Building upon the Kindergarten expectations, all students in **Grade 1** will be able to:	Building upon the K-1expectations, all students in **Grade 2** will be able to:	Building upon the K-2 expectations, all students in **Grade 3** will be able to:
Enduring Understanding: The structures of materials determine their properties. Observe and describe the properties of a variety of non-living materials using the senses (i.e., sight, touch, smell, hearing). Use the physical properties of non-living materials (e.g., texture, size, shape, color) to describe similarities and differences. Sort, group, and regroup a variety of familiar non-living materials based on their physical properties (e.g., shape, color, texture, size). Use a hand lens (magnifier) to inspect a variety of non-living materials and demonstrate through discussion or drawings how the lens extends the sense of sight. Construct simple class graphs (e.g., pictographs, physical graphs) to organize information.	**Enduring Understanding: The structures of materials determine their properties.** Conduct simple investigations to identify the physical properties (e.g., ability to sink or float, dissolve in water, roll or stack) of solids and liquids. Record the results on charts, diagrams, graphs, and/or drawings. Sort and group solids based on physical properties such as color, shape, ability to roll or stack, hardness, magnetic attraction, or whether they sink or float in water. Compare and describe similarities and differences in physical properties of various solid objects. Sort and group liquids based on physical properties such as color, odor, tendency to flow, and whether they sink, or float. Compare and describe similarities and differences in physical properties of various liquids.	**Enduring Understanding: The structures of materials determine their properties.** Use an equal arm balance to weigh and compare a variety of objects and recognize that weighing is the process of balancing an object against a certain number of standard units. Predict the serial order for the weights of a variety of objects and test these predictions by weighing the objects. Recognize that equal volumes of different materials may have different weights.	**Enduring Understanding: The structures of materials determine their properties.** Explore evaporation and condensation. Identify the changes of state from liquid to gas in evaporation and gas to liquid in condensation using water as an example. Observe and describe changes in the properties of water as it changes from solid to liquid to gas.

Standard 2: Materials and Their Properties, Grade Level Expectations Grades K-3

Essential Question: How do the properties of materials determine their use?
Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?

Enduring Understanding: The structures of materials determine their properties.
Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.

All students in **Kindergarten** will be able to:	Building upon the Kindergarten expectations, all students in **Grade 1** will be able to:	Building upon the K-1expectations, all students in **Grade 2** will be able to:	Building upon the K-2 expectations, all students in **Grade 3** will be able to:
Interpret and describe simple graphs constructed by the class. Use non-standard units of measure (e.g., string, paper clips) to compare the size and weight of non-living materials. Observe and describe changes in the physical properties of objects that occur when they are exposed to a variety of treatments (i.e., temperature, sunlight, water). **Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.** Observe how materials can be modified for different uses (e.g., paper and wood can be modified to have new properties).	Construct individual and class diagrams (e.g., Venn, pictographs) to compare the similarities and differences between the properties of solids and liquids. Observe and describe changes in the physical properties of solids and liquids after exposure to various treatments (i.e., temperature, sunlight, water). Use writing, drawing, and discussion to communicate observations, descriptions, investigations, and experiences concerning solids and liquids. **Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.** *There are no grade level expectations for this understanding.*	**Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.** *There are no grade level expectations for this understanding.*	**Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.** *There are no grade level expectations for this understanding.*

Standard 2: Materials and Their Properties, Grade Level Expectations Grades 4-5

Essential Question: How do the properties of materials determine their use?
Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures?
Essential Question: How does conservation of mass apply to the interaction of materials in a closed system?
Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?

Enduring Understandings: The structures of materials determine their properties.
Enduring Understanding: The properties of a mixture are based on the properties of its components.
Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.
Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.

Building upon the K-3 expectations, all students in **Grade 4** will be able to:	Building upon the K-4 expectations, all students in **Grade 5** will be able to:
Enduring Understandings: The structures of materials determine their properties. Test objects for their conductivity and classify the objects based on whether they conduct electricity (conductors) or do not conduct electricity (insulators). Test objects for their magnetism and classify objects based on whether they are attracted to a magnet or not attracted to a magnet. Investigate evaporation and condensation. Recognize the relationship between temperature and changes of state from liquid to gas in evaporation and gas to liquid in condensation using water as an example.	**Enduring Understandings: The structures of materials determine their properties.** *There are no grade level expectations for this understanding.*
Enduring Understanding: The properties of the mixture are based on the properties of its components. *There are no grade level expectations for this understanding.*	**Enduring Understanding: The properties of the mixture are based on the properties of its components.** Separate the components of a mixture by using the physical properties of the components and choosing the appropriate processes (e.g., evaporation, filtering). Make and implement a plan to separate mixtures. Revise the plan based on evidence collected. Record and communicate the results. Combine different amounts of solid material and water. Compare the properties of these solutions, (i.e., color, viscosity, clarity). Compare the mass of mixtures and solutions to the mass of their component parts.

Standard 2: Materials and Their Properties, Grade Level Expectations Grades 4-5

Essential Question: How does the structure of materials determine its properties?
Essential Question: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures?
Essential Question: How does conservation of mass apply to the interaction of materials in a closed system?
Essential Question: What determines the type and extent of a chemical reaction?
Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?

Enduring Understandings: The structures of materials determine their properties.
Enduring Understanding: The properties of the mixture are based on the properties of its components.
Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.
Enduring Understanding: There are several ways in which elements and/or compounds react to form new substances and each reaction involves energy.
Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.

Building upon the K-3 expectations, all students in **Grade 4** will be able to:	Building upon the K-4 expectations, all students in **Grade 5** will be able to:
	Determine the quantities of two different materials (e.g., salt and sugar) required to saturate equal volumes of water and compare the results. Recognize that some materials are more soluble in water than other materials.
Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.	**Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.**
There are no grade level expectations for this understanding.	Explain why the total amount of a material remains the same even when exposed to a variety of physical treatments (e.g., flattening or balling up clay, breaking apart a candy bar, pouring liquid into a tall, slender glass vs. a short, fat glass).
Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.	**Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.**
There are no grade level expectations for this understanding.	Research and report on recycling of household materials (e.g., glass, newspaper, plastics) and how these materials are reused.

Standard 2: Materials and Their Properties, Grade Level Expectations Grades 6-8

Essential Question: How do the properties of materials determine their use? Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures? Essential Question: How does conservation of mass apply to the interaction of materials in a closed system? Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?		
Enduring Understanding: The structures of materials determine their properties. Enduring Understanding: The properties of a mixture are based on the properties of its components. Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same. Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.		
Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
Enduring Understanding: The structures of materials determine their properties. *There are no grade level expectations for this understanding.*	**Enduring Understanding: The structures of materials determine their properties.** Recognize that all matter consists of particles and how the particles are arranged determines the physical state. Use the particle model to describe solids, liquids, and gases in terms of the packing and motion of particles. Measure and record the temperature of ice water as it is heated. Plot the graph of measurements taken and interpret the change of phase graph using the particle model, identifying the states of matter. Analyze a standard change of phase graph of water. Using the particle model, identify where water is a solid, liquid or gas, is freezing/melting or evaporating/condensing. Relate the states of matter to the changes (increase, decrease) of energy in the system. Make a model or drawing of particles of the same material in solid, liquid, and gas state. Describe the arrangement, spacing and energy in each state. Distinguish between physical properties that are dependent upon mass (size, shape) and those physical properties such as boiling point, melting point, solubility, density, conduction of heat and pH of a substance or material that are not altered when the mass of the material is changed.	**Enduring Understanding: The structures of materials determine their properties..** Conduct simple investigations in which a variety of materials (sand, water, light colored materials, dark colored materials) are exposed to light and heat energy. Measure the change in temperature of the material and describe any changes that occur in terms of the physical properties of the material. Conduct investigations, using a variety of materials, to show that some materials conduct heat more readily than others. Identify these materials as conductors or insulators. Explain why insulators may be used to slow the change of temperature of hot or cold materials.

Standard 2: Materials and Their Properties, Grade Level Expectations Grades 6-8

Essential Question: How do the properties of materials determine their use?
Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures?
Essential Question: How does conservation of mass apply to the interaction of materials in a closed system?
Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?

Enduring Understanding: The structures of materials determine their properties.
Enduring Understanding: The properties of the mixture are based on the properties of its components.
Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.
Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.

Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
	Calculate the density of various solid materials. Use density to predict whether an object will sink or float in water. Given the density of various solids and liquids, create a density column and explain the arrangement in terms of density. Use physical properties to distinguish and separate one substance or material from another.	
Enduring Understanding: The properties of the mixture are based on the properties of its components. *There are no grade level expectations for this understanding.*	**Enduring Understanding: The properties of the mixture are based on the properties of its components.** Distinguish between homogeneous and heterogeneous mixtures. Using their physical properties, design and conduct an investigation to separate the components of a homogeneous or heterogeneous mixture. Recognize that a homogeneous mixture is a solution. Prepare solutions of different concentrations recognizing that the properties of the solution (color, density, boiling point) depend on the nature and concentration of the solute and solvent. Conduct investigations to determine the effect of temperature and surface area of the solute on the rate of solubility. Describe the rate of solubility using the particle model. Conduct investigations to determine the effect of temperature on saturation point. *(continued on next page)*	**Enduring Understanding: The properties of the mixture are based on the properties of its components.** *There are no grade level expectations for this understanding.*

Standard 2: Materials and Their Properties, Grade Level Expectations Grades 6-8

Essential Question: How do the properties of materials determine their use? Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures? Essential Question: How does conservation of mass apply to the interaction of materials in a closed system? Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?		
Enduring Understanding: The structures of materials determine their properties. Enduring Understanding: The properties of the mixture are based on the properties of its components. Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same. Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.		
Building upon the K-5 expectations, all students in **Grade 6** will be able to:	Building upon the K-6 expectations, all students in **Grade 7** will be able to:	Building upon the K-7 expectations, all students in **Grade 8** will be able to:
Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same. *There are no grade level expectations for this understanding.* **Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.** *There are no grade level expectations for this understanding.*	Construct a solubility curve based on data collected. Describe solubility and saturation point using the particle model. Conduct investigations to demonstrate the process of diffusion. Use the particle model to describe the movement of materials from an area of higher concentration to an area of lower concentration. **Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.** Show that mass is conserved when adding a solute to a solvent (mass of solvent + mass of solute = total mass of solution). **Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.** Select a manufactured item and identify its component materials. Explain how the physical properties of the materials contribute to the function of the item. Discuss the social, economic, and/or environmental consequences of the production of new materials to meet human wants and needs.	**Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.** *There are no grade level expectations for this understanding.* **Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.** *There are no grade level expectations for this understanding.*

Standard 2: Materials and Their Properties, Grade Level Expectations Grades 9-12

Essential Question: How do the properties and structures of materials determine their uses?
Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures?
Essential Question: How does conservation of mass apply to the interaction of materials in a closed system?
Essential Question: What determines the type and extent of a chemical reaction?
Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?

Enduring Understanding: The structures of materials determine their properties.
Enduring Understanding: The properties of the mixture are based on the properties of its components.
Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.
Enduring Understanding: There are several ways in which elements and/or compounds react to form new substances and each reaction involves energy.
Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.

Building upon the K-8 expectations, all students in **Grade 9** will be able to:	Building upon the K-10 expectations, all students in **Grade 11** will be able to:
Enduring Understanding: The structures of materials determine their properties. Explain that matter is composed of tiny particles called atoms that are unique to each element, and that atoms are composed of subatomic particles called protons, neutrons, and electrons. Describe the relative charge, approximate mass, and location of protons, neutrons, and electrons in an atom. Classify matter as mixtures (which are either homogeneous or heterogeneous) or pure substances (which are either compounds or elements.) Explain that elements are pure substances that cannot be separated by chemical or physical means. Recognize that compounds are pure substances that can be separated by chemical means into elements. Classify various common materials as an element, compound or mixture. Describe isotopes of elements in terms of protons, neutrons, electrons, and average atomic masses. Recognize that isotopes of the same element have essentially the same chemical properties that are determined by the proton and electron number. Use the Periodic Table to identify an element's atomic number, valence electron number, atomic mass, group/family and be able to classify the element as a metal, non-metal or metalloid. Determine the physical and chemical properties of an element based on its location on the Periodic Table.	**Enduring Understanding: The structures of materials determine their properties.** Construct models or diagrams (Lewis Dot structures, ball and stick models, or other models) of common compounds and molecules (i.e., NaCl, SiO_2, O_2, H_2, CO_2) and distinguish between ionically and covalently bonded compounds. Based on the location of their component elements on the Periodic Table, explain the elements tendency to transfer or share electrons. Explain why the average atomic mass of an element reflects the relative natural abundance of the element and therefore is not a whole number. Explain that unstable isotopes undergo spontaneous nuclear decay, emitting energy or particles and energy. Compare and contrast the energy released by nuclear reactions to that released by chemical reactions. Describe the composition of alpha, beta, and gamma radiation and the shielding necessary to prevent penetration. Use the half life of a radioactive isotope to calculate the amount of remaining radioactive substance after an integral number of half-lives. Use kinetic molecular theory to explain changes in gas volume, pressure, and temperature. Perform simple calculations to show that if the temperature is held constant, changes in pressure and volume of an enclosed gas have an inverse relationship. (Boyles Law).

Standard 2: Materials and Their Properties, Grade Level Expectations Grades 9-12

Essential Question: How do the properties and structures of materials determine their uses?
Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures?
Essential Question: How does conservation of mass apply to the interaction of materials in a closed system?
Essential Question: What determines the type and extent of a chemical reaction?
Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?

Enduring Understanding: The structures of materials determine their properties.
Enduring Understanding: The properties of the mixture are based on the properties of its components.
Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.
Enduring Understanding: There are several ways in which elements and/or compounds react to form new substances and each reaction involves energy.
Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.

Building upon the K-8 expectations, all students in **Grade 9** will be able to:	Building upon the K-10 expectations, all students in **Grade 11** will be able to:
Enduring Understanding: The structures of materials determine its properties (cont'd). Investigate differences between the properties of various elements in order to predict the element's location on the Periodic Table. Use the Periodic Table to predict the types of chemical bonds (e.g., ionic or covalent) in a variety of compounds. Use models or drawings to illustrate how molecules are formed when two or more atoms are held together in covalent bonds by "sharing" electrons. Use models or drawings to illustrate how ionic compounds are formed when two or more atoms "transfer" electrons and are held together in ionic bonds. Explain how an atom's electron arrangement influences its ability to transfer or share electrons and is related its position on the periodic table. Recognize that an atom in which the positive and negative charges do not balance is an ion. Recognize that metals have the physical properties of conductivity, malleability, luster, and ductility. Explore the extent to which a variety of solid materials conduct electricity in order to rank the materials from good conductors to poor conductors. Based on the conductivity data, determine patterns of location on the Periodic Table for the good conductors versus the poor conductors. Recognize that physical changes alter some physical properties of a substance but do not alter the chemical composition of the substance.	**Enduring Understanding: The structures of materials determine its properties (cont'd).** Perform simple calculations to show that if the pressure is held constant, changes in temperature (in Kelvin) and volume of an enclosed gas have a direct relationship. (Charles Law). Perform simple calculations to show that if the volume is held constant, changes in pressure and temperature (in Kelvin) of an enclosed gas have a direct relationship (Gay-Lussac's Law). Use the Periodic Table to show trends within periods and groups (families) regarding atomic size, size of ions, ionization energies and electronegativity.

Standard 2: Materials and Their Properties, Grade Level Expectations Grades 9-12

Essential Question: How do the properties and structures of materials determine their uses?
Essential Questions: How can the properties of the components of a mixture be used to separate the mixture? How do the components determine the properties of mixtures?
Essential Question: How does conservation of mass apply to the interaction of materials in a closed system?
Essential Question: What determines the type and extent of a chemical reaction?
Essential Questions: How do you know which material is best for a particular product or need? What determines if new materials need to be developed? Why should people consider the risks and benefits before the production of new materials and/or the implementation of a new process?

Enduring Understanding: The structures of materials determine their properties.
Enduring Understanding: The properties of the mixture are based on the properties of its components.
Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.
Enduring Understanding: There are several ways in which elements and/or compounds react to form new substances and each reaction involves energy.
Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.

Building upon the K-8 expectations, all students in **Grade 9** will be able to:	Building upon the K-10 expectations, all students in **Grade 11** will be able to:
Enduring Understanding: The structures of materials determine its properties (cont'd). Conduct investigations to determine the effect of heat energy on the change of state (change of phase) of water. Sketch and interpret graphs representing the melting, freezing, evaporation and condensation of water. Recognize that molecular and ionic compounds are electrically neutral. Apply the kinetic molecular theory to explain that a change in the energy of the particles may result in a temperature change or a change of phase (change in state). Use a model or a diagram to explain water's properties (e.g., density, polarity, hydrogen bonding, boiling point, cohesion, and adhesion) in the three states of matter. Cite specific examples of how water's properties are important (i.e., water as the "universal"). **Enduring Understanding: The properties of the mixture are based on the properties of its components.** Recognize that mixtures can be separated by physical means into pure substances. Explain the effect of water's polarity on the solubility of substances (e.g., alcohol, salt, oil). Separate mixtures into their component parts according to their physical properties such as melting point, boiling point, magnetism, solubility and particle size. Explain how the properties of the components of the mixture determine the physical separation techniques used.	**Enduring Understanding: The properties of the mixture are based on the properties of its components.** Express the concentration of various solutions in terms of the amount of solute dissolved in the solvent (molarity). Collect data to calculate the unknown concentration of a solution by performing an acid-base titration using an appropriate indicator. Describe neutralization reactions using chemical equations.

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Building upon the K-8 expectations, all students in **Grade 9** will be able to:	Building upon the K-10 expectations, all students in **Grade 11** will be able to:
Enduring Understanding: The properties of the mixture are based on the properties of its components (cont'd). Describe how the process of diffusion or the movement of molecules from an area of high concentration to an area of low concentration (down the concentration gradient) occurs because of molecular collisions. Explore how various solutions conduct electricity and rank the liquids from good conductors to poor conductors. Explain the characteristics that allow some solutions to have better electrical conductivity than others. Measure the pH of a solution using chemical indicators to determine the relative acidity or alkalinity of the solution. Identify the physical properties of acids and bases. Investigate factors that affect the materials' solubility in water and construct solubility curves to compare the extent to which the materials dissolve. **Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.** Conduct and explain the results of simple investigations to demonstrate that the total mass of a substance is conserved during both physical and chemical changes.	**Enduring Understanding: When materials interact within a closed system, the total mass of the system remains the same.** Recognize that one mole is the amount of any substance that contains 6.02×10^{23} (Avogadro's number) representative particles of that substance. This quantity of particles will have the mass equivalent to the molecular weight (molar mass). Express various quantities of matter in terms of moles (e.g., 6.0 g carbon = .50 moles of carbon; 36 g H_2O = 2.0 moles H_2O).

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Building upon the K-8 expectations, all students in **Grade 9** will be able to:	Building upon the K-10 expectations, all students in **Grade 11** will be able to:
Enduring Understanding: There are several ways in which elements and/or compounds react to form new substances and each reaction involves energy. Recognize that chemical changes alter the chemical composition of a substance forming one or more new substances. The new substance may be a solid, liquid, or gas. Balance simple chemical equations and explain how these balanced chemical equations represent the conservation of matter.	Determine how the mass of the products compares to the mass of the reactants in chemical investigations. Show how this comparison links to the appropriate balanced chemical equation. **Enduring Understanding: There are several ways in which elements and/or compounds react to form new substances and each reaction involves energy.** Conduct experiments and provide evidence (e.g., formation of a precipitate, evolution of gas, change of color, release/absorption of energy in the form of heat, light, or sound) to determine if a chemical reaction has occurred. Identify, name and write formulae for covalent and ionic compounds. Describe chemical reactions using correct chemical formulae and balance the resulting chemical equation. Classify various reactions as synthesis (combination), single replacement, double replacement, decomposition or combustion. Explain whether or not a chemical reaction would occur given a set of reactants. Predict the product(s) if the reactions would occur. Investigate factors (e.g., presence of a catalyst, temperature, concentration) that influence reaction rates. Analyze reaction diagrams for some common chemical reactions to compare the amount of heat energy absorbed by the reaction to the amount of heat energy released. Explain, using the diagrams, that if the products of the reactions are at a higher level than the reactants, the reaction has absorbed heat energy (endothermic), but if the products of the reaction are at a lower level than the reactants, then heat energy has been released (exothermic).

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Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment. Research and report on a variety of manufactured goods and show how the chemical properties of the component materials were used to achieve the desired qualities.	Use energy diagrams to explain the effect of a catalyst on activation energy. **Enduring Understanding: People develop new materials as a response to the needs of society and the pursuit of knowledge. This development may have risks and benefits to humans and the environment.** Identify polymers as large molecules with a carbon backbone. Recognize that polymers are comprised of repeating monomers. Investigate synthetic and naturally occurring polymers and relate their chemical structure to their current or potential use. Research and report on materials that are used in response to human and societal needs. These materials might include but are not limited to synthetic polymers such as Kevlar or Gortex; or radioactive isotopes such as U^{235}, or C^{14}, etc… Recognize the intended (and realized) benefits as well as any risks or trade-offs required in their production and use.