The Next Generation Science Standards (NGSS)

CHAPTER 1, LESSON 1 – MOLECULES MATTER

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.

DISCIPLINARY CORE IDEAS

PS1.A: Structure and Properties of Matter

- 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)

  By observing water beading up on wax paper and food coloring spreading in water, students are introduced to the idea that a liquid (water) is made of particles that are close together, attracted to each other, and in constant motion. The characteristics of gasses and solids are addressed in later lessons in Chapter 1.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1), (MS-PS1-4)

Engaging in Argument from Evidence

Students investigate the question: Does water hold together well or come apart easily? After making observations of the behavior of water, students are introduced to a molecular model animation of water molecules. Students use and further develop this molecular model and apply it to evidence they have observed to explain their observations on the molecular level and to answer the question to investigate.

CROSSCUTTING CONCEPTS

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

  Students use molecular-level models to explain how these sub-microscopic characteristics affect how water behaves on the macroscopic level.

The Next Generation Science Standards (NGSS)

CHAPTER 1, LESSON 2 – MOLECULES IN MOTION

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.

DISCIPLINARY CORE IDEAS

PS1.A: Structure and Properties of Matter

- 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)

Students add food coloring to hot and cold water. Students further develop their understanding of the motion, attraction, and arrangement of the molecules of a liquid by observing the relative amount of mixing in the hot and cold water. The motion, attraction, and arrangement of the molecules in solids and gasses are addressed in later lessons in Chapter 1.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1), (MS-PS1-4)

Planning and Carrying Out Investigations

Engaging in Argument from Evidence

Students investigate the question: Is the speed of water molecules different in hot and cold water? Students help design an experiment to see if heating and cooling water affects the motion of the water molecules. Students see an enhanced molecular model animation in which the molecules move faster and slightly further apart when heated, and slower and closer together when cooled. Students use and further develop this molecular model and apply it to evidence they have observed to explain their observations on the molecular level and to answer the question to investigate.

CROSSCUTTING CONCEPTS

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

Students see and apply the cause and effect relationship between heating and cooling and the motion and arrangement of molecules. Students use molecular models to explain how heating and cooling on the molecular level affects how water behaves on the macroscopic level.

The Next Generation Science Standards (NGSS)

CHAPTER 1, LESSON 3 – THE UPS AND DOWNS OF THERMOMETERS

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.

DISCIPLINARY CORE IDEAS

PS1.A: Structure and Properties of Matter

- 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)
- 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)

Students observe the red liquid (colored alcohol) in a thermometer placed in hot and cold water. Students use their observations and what they have learned so far about the motion of molecules in a liquid to understand the up and down movement of the liquid in the thermometer based on the motion and arrangement of alcohol molecules when they are heated and cooled. Students also see that mercury and alcohol rise to different heights in a thermometer even at the same temperature. This indicates that mercury and alcohol have characteristic properties based on the atoms and molecules they are composed of.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1), (MS-PS1-4)

Engaging in Argument from Evidence

Students investigate the question: What makes the liquid in a thermometer go up and down? Along with observing the movement of the liquid in the thermometer, students see a molecular animation modeling the motion of the molecules when they are heated and cooled. Students use and further develop this molecular model and apply it to evidence

they have observed to explain their observations on the molecular level and to answer the question to investigate.

CROSSCUTTING CONCEPTS

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

Structure and Function

- 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)

Students see and apply the cause and effect relationship between heating and cooling and the motion and arrangement of molecules. Students use a molecular-level explanation to explain the macroscopic effect of the rising and falling of the liquid in a thermometer. Students also see that a thermometer is a cleverly-designed device whose very thin glass tube-within-a-tube and special liquid can be used to indicate changes in temperature.

The Next Generation Science Standards (NGSS)

CHAPTER 1, LESSON 4 – MOVING MOLECULES IN A SOLID

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.

DISCIPLINARY CORE IDEAS

PS1.A: Structure and Properties of Matter

- 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)
- Solids may be formed from molecules, or they may be extended structures with repeating sub-units (e.g. crystals). (MS-PS1-1)

Students observe a metal ball-and-ring demonstration in which the ball is heated and cooled. The ball fits through the ring at room temperature but becomes too large to fit through when heated. Students apply what they've learned so far to begin to understand the attractions, arrangement, and motion of the atoms in a solid and how these properties are affected when the solid is heated and cooled.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1), (MS-PS1-4)

Engaging in Argument from Evidence

Students investigate the question: How does heating and cooling affect the atoms of a solid? In addition to observing the actual metal ball and ring, students see a molecular model animation of a solid being heated and cooled. Students use and further develop this molecular model and apply it to evidence they have observed to explain their observations on the molecular level and to answer the question to investigate.

CROSSCUTTING CONCEPTS

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

Structure and Function

- 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)

Students see and apply the cause and effect relationship between heating and cooling and the motion and arrangement of molecules. Students use a molecular-level explanation to explain the macroscopic effect of the ball expanding and contracting when it is heated and cooled. Students also see that the expanding and contracting of a solid is a problem in road construction on bridges. Students see that scientists and engineers have developing flexible materials and movable joints to solve this problem.

The Next Generation Science Standards (NGSS)

CHAPTER 1, LESSON 5 – AIR, IT'S REALLY THERE

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.

DISCIPLINARY CORE IDEAS

PS1.A: Structure and Properties of Matter

- 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)
- Gases and liquids are made of molecules or inert atoms that are moving about relative to each other. (MS-PS1-4)

Students observe a bubble expanding and contracting on top of a bottle when the bottle is placed in hot and then in cold water. Students use this observation and what they have learned about the atoms and molecules in liquids and solids to begin to develop their understanding of the attraction, motion, and arrangement of the molecules in a gas.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to predict and/or describe phenomena. (MS-PS1-1), (MS-PS1-4)

Engaging in Argument from Evidence

Students investigate the question: How does heating and cooling affect a gas? In addition to observing the bubble growing and shrinking as the gas is heated and cooled, students see a molecular model animation of the heating and cooling of the gas inside the bottle. Students use and further develop this molecular model and apply it to evidence they have observed to explain their observations on the molecular level and to answer the question to investigate.

CROSSCUTTING CONCEPTS

Cause and Effect

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)

Students see and apply the cause and effect relationship between heating and cooling and the motion and arrangement of molecules. Students use a molecular-level explanation to explain the macroscopic effect of the bubble expanding and contracting when it is heated and cooled. Students also see that the expanding and contracting of a solid is a problem in road construction on bridges. Students see that scientists and engineers have developing flexible materials and movable joints to solve this problem.

