

The Next Generation Science Standards (NGSS)

CHAPTER 2, LESSON 1 – HEAT, TEMPERATURE, AND CONDUCTION

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

PS3.A: Definitions of Energy

- Temperature is a measure of the average kinetic energy of particles of matter. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter present. (MS-PS3-3), (MS-PS3-4)
- The term “heat” as used in everyday language refers to both thermal energy (the motion of atoms or molecules within a substance) and the transfer of that thermal energy. In science, heat is used only for this second meaning; it refers to the energy transferred due to the temperature difference between two objects. (MS-PS1-4)

Students place heated metal washers in room-temperature water and measure the temperature change of the water and the washers. Students begin to develop the understanding that temperature is related to the motion of atoms and molecules and that heat is transferred from a substance at a higher temperature to a substance at a lower temperature.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

- Develop a model to describe unobservable mechanisms. (MS-PS3-2)

Engaging in Argument from Evidence

Students investigate the question: Does the temperature of an object change when it is placed in hot water? Along with heating and taking temperature readings of metal washers and water, students see a molecular model animation depicting conduction on the molecular level. 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 observed change in temperature.

The Next Generation Science Standards (NGSS)

CHAPTER 2, LESSON 2: CHANGING STATE - EVAPORATION

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)
- 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)

Students observe a drop of water on a paper towel placed on a warm surface and another placed on a room temperature surface. Students use their observations and what they have learned so far about the attractions, motion, and arrangement of molecules in a liquid and a gas to begin to develop an understanding of the process of evaporation.

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

Planning and Carrying Out Investigations

Asking Questions and Defining Problems

Students investigate the question: Does adding energy increase the rate of evaporation? Students help design an experiment to see if heating water affects the rate of evaporation. Students see a molecular model animation of the process of evaporation. 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 water, the motion of molecules, and the rate of evaporation. Students use molecular models to explain how heating on the molecular level affects the observed evaporation rate on the macroscopic level.

The Next Generation Science Standards (NGSS)

CHAPTER 2, LESSON 3: CHANGING STATE - CONDENSATION

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)
- 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)

Students discuss examples of condensation and then observe a sample of water vapor changing state to liquid water on the side of a cup. Students use their observations and what they have learned so far about the attractions, motion, and arrangement of molecules in a liquid and a gas and how they are affected when heated and cooled to begin to develop an understanding of the process of condensation.

SCIENCE AND ENGINEERING PRACTICES

Developing and Using Models

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

Asking Questions and Defining Problems

Planning and Carrying Out Investigations

Engaging in Argument from Evidence

Students investigate the question: What happens when water vapor condenses? Students help design an experiment to see if cooling water vapor affects the rate of condensation. Students see a molecular model animation of the process of condensation. 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.

CROSCUTTING 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 cooling, decreasing the motion of molecules, and the molecules condensing to form a liquid. Students use a molecular-level explanation to explain the macroscopic effect of the water vapor changing to liquid water on the side of the cup. Students also see that a system can be designed to use the process of condensation to purify water.

The Next Generation Science Standards (NGSS)

CHAPTER 2, LESSON 4: CHANGING STATE – FREEZING

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)
- Solids may be formed from molecules, or they may be extended structures with repeating sub-units (e.g. crystals). (MS-PS1-1)
- 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)
- 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 use ice and salt to make a can cold enough so that water vapor from the air condenses and then freezes on the outside of the can. Students also see a demonstration showing that when water freezes to form ice, the ice takes up more space than the water did before it was frozen. Students use their observations and what they have learned so far about the motion, attractions, and arrangement of molecules in a liquid and in a solid to begin to understand this observation. Students learn that the open crystal structure formed by water molecules as water freezes is contrary to what would be expected. Students also see that different substances have characteristic temperatures at which they freeze based on the molecules they are made 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: How can you make the water vapor in air condense and then freeze? After seeing ice form on the outside of a cold can, students see a molecular model of the arrangement of water molecules in ice. 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.

CROSCUTTING 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 cooling, decreasing molecular motion, and the molecules moving apart and becoming fixed to form a solid. Students use a molecular-level explanation to explain the macroscopic effect of the water vapor changing to liquid water on the side of the cold can and then freezing to form ice.

The Next Generation Science Standards (NGSS)

CHAPTER 2, LESSON 5: CHANGING STATE - MELTING

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

Students see a demonstration showing ice melting quickly on a piece of steel and slowly on a piece of Styrofoam. Students have a class discussion about the source of the heat that is melting the ice and why the melting is faster on the steel. Students warm ice by putting it in water and use their observations, the discussion, and what they have learned so far about the motion, attractions, and arrangement of molecules in a liquid and in a solid to begin to understand the process of melting.

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

Asking Questions and Defining Problems

Engaging in Argument from Evidence

Students investigate the question: Will placing ice in water make it melt faster? Students help design an experiment to see if warming ice by putting it in water increases the rate of melting. Students see a molecular model animation and use a 3-D model of their own to better understand how and why ice changes from a solid to a liquid. 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.

CROSCUTTING 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 warming, increasing molecular motion, and the molecules becoming unfixed, and moving closer together to form a liquid. Students use a molecular-level explanation to explain the macroscopic effect of the ice changing to liquid water.