

# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 1: WATER IS A POLAR MOLECULE

**MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**

### DISCIPLINARY CORE IDEAS

#### *PS1.A: Structure and Properties of Matter*

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)
- The changes of state that occur with changes in temperature or pressure can be described and predicted using these models of matter. (MS-PS1-4)

*Students put water and alcohol on brown paper towel and see that the liquids have different rates of evaporation. Students learn that the covalently bonded atoms in water and alcohol molecules make water a polar molecule and alcohol less polar which helps account for the difference in evaporation rate. Students see that the evaporation rate is a characteristic property that can be used to identify the liquids.*

### SCIENCE AND ENGINEERING PRACTICES

#### *Developing and Using Models*

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

#### *Planning and carrying out investigations*

#### *Engaging in argument from evidence*

*Students investigate the question: Does water evaporate faster or slower than alcohol? Students plan and conduct a simple evaporation test between water and alcohol on a brown paper towel. After observing that alcohol evaporates faster than water, students see a molecular model illustration of water and alcohol showing that water is more polar than alcohol. 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 of water and alcohol to explain how these sub-microscopic characteristics affect the macroscopic observable characteristic of different evaporation rates.*

# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 2: SURFACE TENSION

**MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**

### DISCIPLINARY CORE IDEAS

*PS1.A: Structure and Properties of Matter*

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)

*Students apply what they have learned about the structure and polarity of water and alcohol molecules and how this relates to surface tension. Students see that the surface tension of water and isopropyl alcohol is different and that surface tension is a characteristic property that can be used to distinguish between the two substances.*

### SCIENCE AND ENGINEERING PRACTICES

*Developing and Using Models*

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

*Planning and carrying out investigations*

*Analyzing and interpreting data*

*Engaging in argument from evidence*

- Students investigate the question: How much water can you add to a full test tube? Students plan and conduct a simple surface tension test between water and alcohol on the surface of a penny. After observing that more water than alcohol can be placed on the penny, students see how much water they can add beyond the top rim of a test tube. Students then see a molecular model of the interaction between water molecules at the surface of a drop of water. 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 of water and alcohol to explain how these sub-microscopic characteristics affect the macroscopic observable characteristic of differences in surface tension.*

# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 3: WHY DOES WATER DISSOLVE SALT?

**MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**

### 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)
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)

*Students see that the process of dissolving involves the attraction and interaction of the molecules of the liquid and the solid. Students see that water is better than alcohol at dissolving sodium chloride (salt). Students look at illustrations and animations of these substances on the molecular level and see that a liquid's ability to dissolve a substance is a characteristic property that can be used to identify the liquid.*

### 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 alcohol better, worse, or as good as water at dissolving salt? Students plan and conduct a simple dissolving test to see whether water or alcohol is a better dissolver of salt. After observing that water dissolves more salt than alcohol does, students see molecular models of salt and water and their interaction in dissolving. 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 use molecular-level models of water and alcohol to explain how these sub-microscopic characteristics affect the macroscopic observable characteristic of differences in their ability to dissolve salt.*

# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 4: WHY DOES WATER DISSOLVE SUGAR?

**MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**

### 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)
- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)

*Students see that water is better than alcohol at dissolving sucrose (sugar). Students look at illustrations and animations of these substances on the molecular level and see that the process of dissolving involves the attraction and interaction of the molecules of the liquid and the solid. Students see that a liquid's ability to dissolve a substance is a characteristic property that can be used to identify the liquid.*

### 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 water, alcohol, or oil better at dissolving the sugar coating from an M&M? Students plan and conduct a simple dissolving test to see whether water or alcohol is a better dissolver of sugar. After observing that water dissolves more sugar than alcohol does, students see molecular models of sugar and water and their*

*interaction in dissolving. Students also see molecular models of alcohol and oil. Students use and further develop these molecular models and apply them 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 use molecular-level models of water and alcohol to explain how these sub-microscopic characteristics affect the macroscopic observable characteristic of differences in their ability to dissolve sugar.*



# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 5: USING DISSOLVING TO IDENTIFY AN UNKNOWN

**MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**

### DISCIPLINARY CORE IDEAS

*PS1.A: Structure and Properties of Matter*

- Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms. (MS-PS1-1)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)

*Students see that the process of dissolving involves the attraction and interaction of the molecules of the liquid and the solid. Students see that four different substances (salt, MSG, Epsom Salt, and sucrose) dissolve to different extents in water. Students look at illustrations of these substances on the molecular level. Students see that the extent to which a substance dissolves in water (solubility) is a characteristic property that can be used to identify the substance.*

### 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*

*Analyzing and interpreting data*

*Engaging in argument from evidence*

*Students investigate the question: Can you identify an unknown using a solubility test? Students plan and conduct a dissolving test to see if they can identify an unknown based on how well it dissolves in water. Students dissolve the unknown (course kosher salt) and four known substances (salt, MSG, Epsom Salt, and sucrose) in the same amount of water to see which dissolves most similarly to the unknown. Students see molecular models of each substance and realize that each substance has its own atoms in a specific arrange-*

*ment to form its own 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.*

## **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 use molecular-level models of different substances to explain how these sub-microscopic characteristics affect the macroscopic observable characteristic of differences in their dissolving in water.*

# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 6: DOES TEMPERATURE AFFECT DISSOLVING?

**MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**

### 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)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)

*Students review the effect of heating and cooling on the motion and arrangement of molecules in a liquid. Students see that the sugar coating of an M&M dissolves faster in hot water than room temperature water, and faster in room temperature than in cold water. They also see that temperature affects the dissolving of sugar more than the dissolving of salt.*

### 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*

*Analyzing and interpreting data*

*Engaging in argument from evidence*

*Students investigate the question: Does the temperature of water affect the amount of coating that dissolves from an M&M? Students plan and conduct an investigation to see if the temperature of water affects the dissolving of the sugar coating of an M&M. Students refer to a molecular model animation they have seen in a previous lesson about how heat affects the motion of 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 of water at different temperatures to explain how these sub-microscopic characteristics affect the macroscopic observable characteristic of more sugar dissolving in hotter water.*

# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 7: CAN LIQUIDS DISSOLVE IN WATER?

**MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**

### 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)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)

*Students compare how well three different liquids (isopropyl alcohol, mineral oil, and corn syrup) dissolve in water. Students see that the process of dissolving involves the attraction and interaction of the molecules of the solute and the solvent, whether they are a solid and a liquid, or two liquids. Students see that the extent to which these liquids dissolve in water is a characteristic property of the liquid.*

### 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: Do isopropyl alcohol, mineral oil, and corn syrup dissolve in water? Students plan and conduct an investigation to compare the dissolving of isopropyl alcohol, mineral oil, and corn syrup in water. Students use molecular model illustrations showing the relative polarity of the substances. 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 of isopropyl alcohol, mineral oil, corn syrup, and water to explain how these sub-microscopic characteristics affect the macroscopic observable characteristic of the substances dissolving differently in water.*

# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 8: CAN GASES DISSOLVE IN WATER?

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.

### 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)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)

*Students experiment with club soda and see that it is composed of water with carbon dioxide (CO<sub>2</sub>) gas dissolved in it. Students see that the process of dissolving involves the attraction and interaction of the molecules of the solute with the solvent whether they are solid and liquid or gas and liquid. Students use what they know about the polarity of water molecules and the structure of carbon dioxide to understand why carbon dioxide dissolves in water. Students also see that as the temperature rises, less carbon dioxide stays dissolved in the water.*

### 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*

#### *Analyzing and interpreting data*

#### *Engaging in argument from evidence*

*Students investigate the question: Does carbon dioxide stay dissolved better in water that is warmed or water that is cooled? Students plan and conduct an investigation to see if*

*temperature affects the amount of carbon dioxide that stays dissolved in water. Students use molecular models of water and carbon dioxide and what they know about the motion of molecules when they are heated and cooled to model the attraction and interaction of water and carbon dioxide. 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 use molecular-level models of water and carbon dioxide to explain how these sub-microscopic characteristics affect the macroscopic observable characteristic of carbon dioxide being less soluble as the temperature of water increases.*



# The Next Generation Science Standards (NGSS)

## CHAPTER 5, LESSON 9: TEMPERATURE CHANGES IN DISSOLVING

**MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**

### 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)
- Each pure substance has characteristic physical properties (for any bulk quantity under given conditions) that can be used to identify it. (MS-PS1-3)

*Students dissolve calcium chloride and potassium chloride in water. Students see a different temperature change for each substance. Students see that the temperature change associated with dissolving a particular substance is a characteristic property of that substance.*

### 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*

*Analyzing and interpreting data*

*Engaging in argument from evidence*

*Students investigate the question: Which solute dissolves the most endothermically and the most exothermically? Students plan and conduct an investigation and see that dissolving different substances in water results in different temperature changes. Students use molecular model animations to explain why the dissolving process can result in a change in temperature. Students use the model to explain dissolving which is exothermic (net energy releasing) and dissolving which is endothermic (net energy absorbing). 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 processes affect the macroscopic observable characteristic of the temperature increasing or decreasing during the process of dissolving.*