Chemistry Model Lesson

Student Edition

Matter Matters

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Chemistry Model Lesson: Matter Matters

Introduction
Why does the chair you are sitting on support you? Could a glass of milk support your weight? How about a breath of air? Of course not! You could not sit on milk nor could you drink a chair. What do these examples tell you?

They tell you that matter matters. The materials of your everyday life exist in different states called phases of matter. The phases of matter are important to the way matter behaves.

In this lesson, you and your classmates will learn about the phases of matter: gas, liquid, and solid. You will learn how to link what you see at the visible level (macroscopic) to the causes of what you see at the invisible level (molecular) (see figure 1). Along the way, you will explain what you know with words, sketches, and graphic organizers.

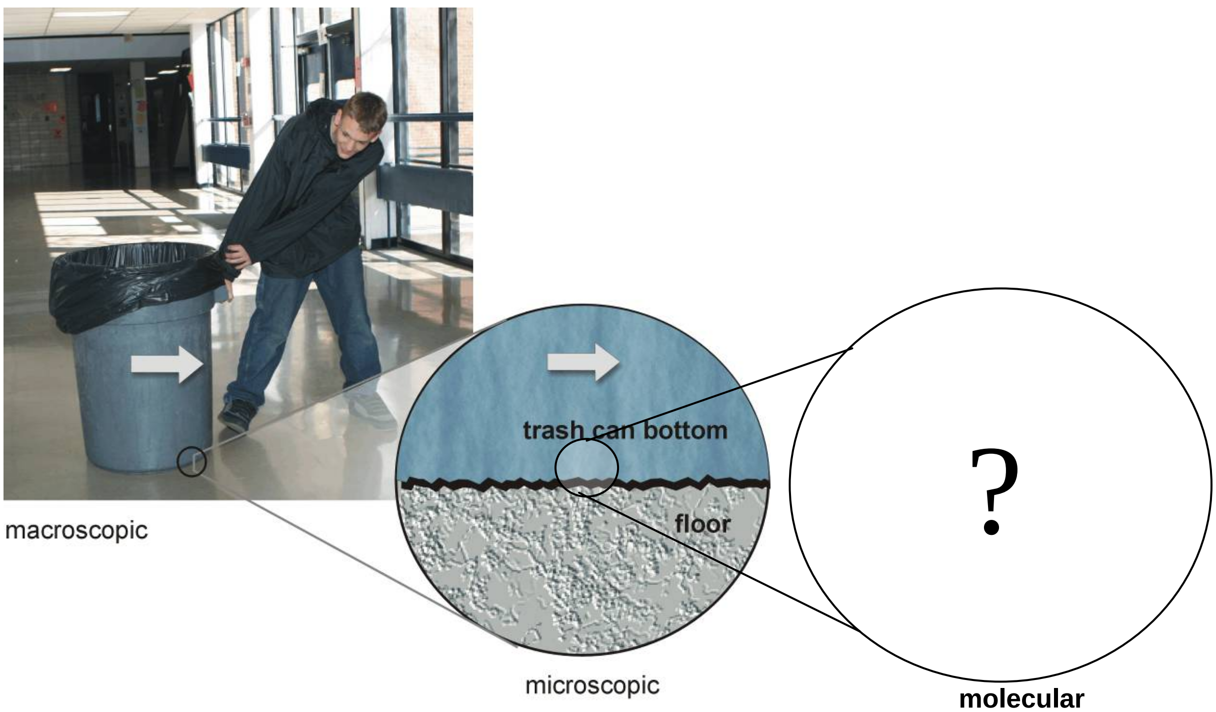

Figure 1: Macroscopic, microscopic and molecular view of friction. What do you feel when you attempt to drag a heavy trash can across the floor? Why is the task easier for a light weight can? How can you explain your experiences from a microscopic view? How can you explain your experiences from a molecular view?

As a result of what you learn in this lesson, you will be able to answer important questions such as:

- What are the macroscopic characteristics of liquids, solids, and gases?
- How does the behavior of particles at the atomic scale explain macroscopic characteristics of solids, liquids, and gases?
- What are effective ways to model microscopic particles in order to understand their behavior?
- How does understanding phases of matter explain the behavior of a burning candle?

To help you learn what you need to know to answer these questions, this lesson is divided into five activities, each with their own title.

Engage: Burning Question
Explore: It Seems Evident
Explain: It's Just a Phase
Elaborate: Super Model
Evaluate: Back to the Candle

Graphic Organizer

A map helps you get to where you are going. It works because it tells you where you are relative to the destination you have in mind. Step by step, you chart your course to reach your goal. It's the same way learning science. Except the map is a graphic organizer that lets you know where you are in a lesson relative to a learning goal. Look at your graphic organizer for this lesson each day. Use it to think about where you have been and where you are going. Monitor your own progress so when you reach your goal, you will know how much you have learned.

Matter Matters

ENGAGE – Burning Question
Key Idea: You can activate prior knowledge by making careful observations about phases of matter in a candle.

Linking Question: How do I use trends in my observations to characterize phases of matter?

EXPLORE – It Seems Evident
Key Idea: Patterns of observations help you form general characteristics used to describe and define phases of matter.

Linking Question: Do general characteristics at the macroscopic scale have a microscopic explanation?

EXPLAIN – It's Just a Phase
Key Idea: Understanding particle behavior at the microscopic scale helps you explain macroscopic characteristics of matter.

Linking Question:
How can I apply my knowledge of microscopic particles to a physical model of phases of matter?

ELABORATE – Super Model
Key Idea: Representing microscopic particles with students in a classroom deepens your understanding of matter.

Linking Question: How can I link prior knowledge, new explanations, and models to demonstrate understanding of phases of matter in a burning candle?

EVALUATE – Back to the Candle
Key Idea: Building on prior knowledge with new understandings helps you demonstrate what you know about phases of matter.

Model Lesson Main Concepts

- Matter commonly exists in three phases: solid, liquid, and gas.
- Each phase of matter has general characteristics, different from one another.
- Macroscopic properties are explained by the behavior of microscopic particles.
- Scientists use inquiry to understand and explain the natural world.

Student Pages

Engage
Burning Question

Everyday objects are made of matter. And that matter exists in three phases—gas, liquid, and solid. So you already know a lot about phases of matter based on your experiences. But you can always build on your prior knowledge by making careful observations. That is what scientists do to learn more about the natural world. That is what you will do in this part of the lesson.

In *Burning Question*, you will observe matter in three phases. You will look for ways to tell phases apart based on characteristics you can see. You will call the characteristics you can see **macroscopic** observations.

Process and Procedure

1. Observe the burning candle that your teacher is demonstrating for class. Make a large sketch of what you see. Use Steps 1a–b and Figure 2 to guide your sketch-making.

   Your sketch of the candle should cover at least ½ page in your science notebook, and will need room for labels as shown in Figure 2. Feel free to ask the names of certain candle parts. Common parts of a burning candle include: wax, wick, bowl, and flame. Draw an arrow from your label to the candle part.

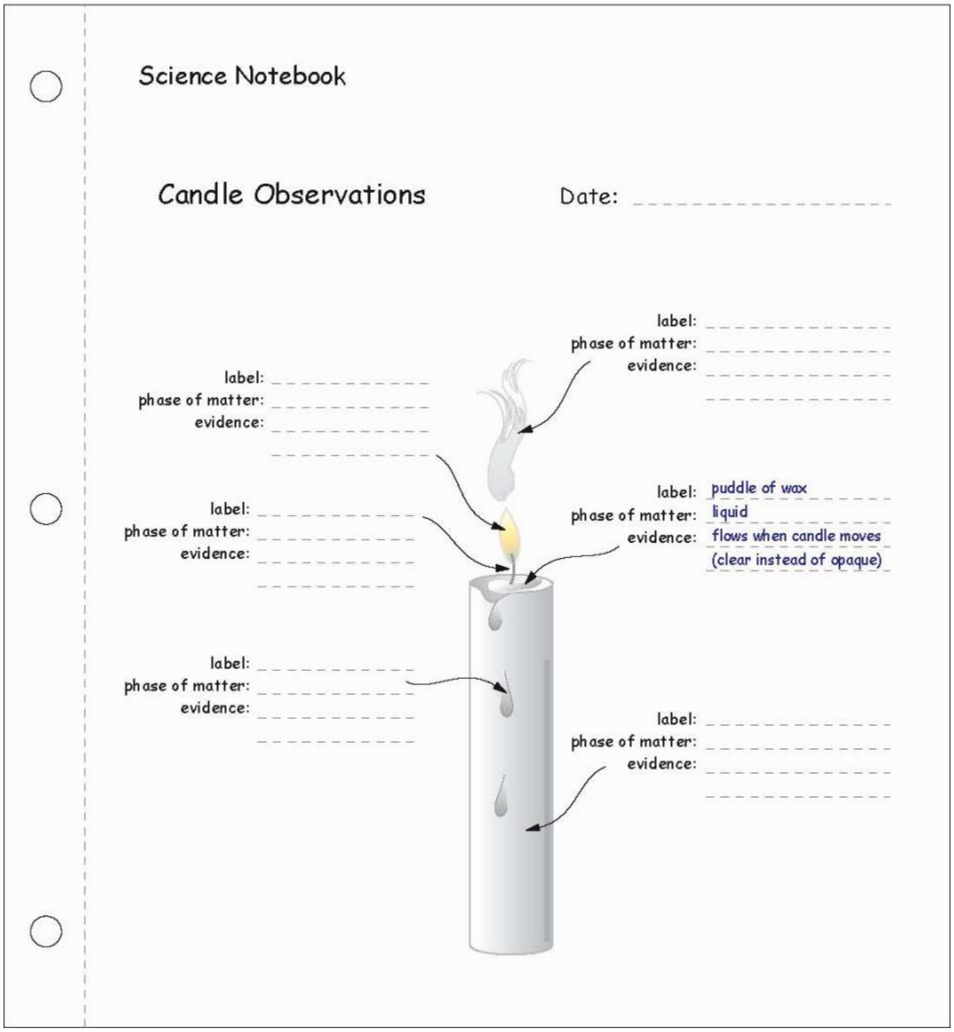

Figure 2: Candle-part labeling examples. Organizing your observations with clear and understandable labels helps you remember.

a. Under each label, write the words *phase of matter* and identify that specific candle part's phase of matter.

There are three common phases of matter: gas, liquid, and solid. Phases of matter are also called *states of matter*.

b. Under the words *phase of matter*, write the word *evidence*. Next to this word describe what you see that supports your idea about the phase of matter.

Evidence can include information from your five senses. Touch and sight are the primary sources of evidence in *Burning Question*.

2. Make a new sketch of what you see as your teacher blows out the flame and places a burning match in the white trail that rises from the glowing wick.

3. Use Step 1 as a guide to write comments on your new sketch.

   Tell what you see and explain what it means. These kinds of comments are sometimes called *highlight comments*.

4. Explain to a teammate all parts of both sketches. Listen as a teammate explains his or her sketches.

5. Make a table with three columns in your science notebook. Use the headings: Solid, Liquid, and Gas. Brainstorm with your teammate to generate a list of at least 5 examples of each phase of matter you can think of. Place your examples in the correct column.

Reflect and Connect

Read each question carefully before you answer it in your notebook. After you record your best thinking, check your answers as your teacher instructs.

1. You have heard and used the word *phase* in everyday life. For example, the Moon goes through different phases monthly. Or a friend might be in a bad mood and you say, "Oh, he's just going through a phase." Compare and contrast these uses of the word *phase* to the way it is used in this activity.

2. In Step 5, you and a teammate placed examples in different columns based on the phase of matter. Describe what you did when you were unsure or disagreed about where to place an example. If you did not disagree, describe the way you used observations to place each example in the correct column.

Explore
It Seems Evident

Phases of matter show up in everyday objects like burning candles. In *Burning Questions,* you used careful observations and prior knowledge to tell one phase of matter from another. That is, you characterized phases of matter by what you saw. But are the characteristics of solid candle wax the same as the characteristics of solid water (ice)? How about liquid candle wax and salad oil?

In *It Seems Evident*, you and your team will look for general ways to describe phases of matter that apply to all substances. You will do this by looking for trends or patterns in observations that you make.

Process and Procedure

1. Read the following paragraph to learn one way scientists think about evidence.

   Scientists reach conclusions based on evidence. One essential feature of evidence is that different people can make the same observation over and over again. For example, think of a cube of ice. What conclusion would you reach about its phase of matter? Of course, you would place ice in the Solid column in your table in Step 5 from the Engage activity. Which of the following is scientific evidence for your conclusion?

   - The ice cube looks pretty when sunlight hits it.
   - I can set a coin on the ice cube, but the same coin passes through liquid and gaseous water.

2. Participate in an all-class discussion about the last two statements in Step 1. Record 2 or 3 key ideas from the discussion.

3. Select 2 examples from each column in your table of solids, liquids, and gases from Step 5 of the Engage activity, and give evidence for your phase-of-matter decision. Record your evidence under your table.

4. Watch your teacher demonstrate the three phases of water, and record what you see by completing Steps 4a–c.

   a. Observe the three phases of water. Be sure to use drawings and words to record your observations in your science notebook.
   b. Based on your observations, include the 3 phases of water in the columns of your table from Step 5 of the Engage activity.
   c. Explain your labels using the observations as your evidence.

   Don't forget to include an explanation of why you placed evidence in a particular column.

Reflect and Connect

Work with your team to complete the following tasks. Read each task carefully before you work on it. Check your answers as instructed by your teacher.

1. Study the list of examples each team member offered in your table of solids, liquids, and gases from Step 5 of the Engage activity. Write a general set of characteristics of each phase of matter.

   General characteristic refers to features that seem to be true all the time. For example, solids have a definite shape. From your experiences, this statement is true and helps you sort matter into one of three phases.

2. Sketch your initial ideas for each phase of matter from the molecular viewpoint. What do you think matter looks like at the molecular level for each phase of matter?

   Look at the general characteristics you wrote about in Question 1. For your drawing, think of the nature of matter at the molecular level that could explain these general characteristics.

Explain
It's Just a Phase

Finding trends in observations helps you understand phases of matter. For example, all gases share a characteristic—a solid object such as a marble "falls" through a gas. But describing gases does not explain why they behave in characteristic ways.

In *It's Just a Phase*, you and your team will explain why solids, liquids, and gases behave in certain ways, resulting in characteristic properties. That explanation will be based on a molecular-level view point of matter and will involve using models of the tiny particles that make up matter.

Process and Procedure

1. Look ahead to the T-table in Step 5 (figure 6). You will complete this T-table after reading *Water Works!* and engaging in a molecule model activity. The reading will help you understand your teacher's model that represents three phases of matter.

   A T-table is a way to organize your thoughts with graphics (lines and figures instead of words alone). That's why it's also called a graphic organizer.

2. Read *Water Works!* and imagine how particles of matter behave in the solid, liquid, and gas phases. Use an appropriate reading strategy as your teacher instructs.

Water Works!

Water Everywhere
Water flows as a liquid. Water freezes into a solid. Water evaporates or boils to form a gas. Water in all its phases is important on global and local levels. For example, the human body is made up of 55–75 percent liquid water. People use it to cook, bathe, and drink. Water as a solid or liquid is the focal point of many sports and hobbies. Swimming, water skiing, and boating use liquid water. Hockey, figure skating, and snowboarding need solid water. On a global level, water as solid, liquid, and gas plays a key role in the earth's climate and in shaping the land.

So what's so special about water? How can it serve so many functions? Take a closer look—a much closer look. No, closer. Okay, there you go. Now that you're at the molecular level, what do you see? Whether it is a solid, liquid, or gas, we see water molecules at this level. So, what is different at this level for solid, liquid, and gaseous water? Let's answer that question for more than just water; let's look at patterns in the molecules for most substances when they are in different states of matter. Then we will pay closer attention to water.

The Molecular View
What you see at the molecular level are tiny particles (atoms or molecules). These particles are in constant, random motion. They behave like bouncy balls that are free to move and collide with

one another. In addition, they are attracted to each other. The closer the particles are to each other, the greater the attraction between them.

In a gas the particles are at much larger distances from each other than in solids or liquids and the molecules are less affected by forces of attraction. Those forces have little effect on the particles. Large distance and weak attraction between particles are characteristics of the gas phase of matter.

What happens to particles when temperature of the a gas decreases? They slow down and the energy of motion decreases. They don't bounce as far apart. That results in less distance between particles. Particles get so close to each other that their attraction increases. When that happens, a liquid forms (figure 3). That is, water condenses. In the liquid phase of matter, particles are much closer than in the gas phase. But they are still free to move past each other. The temperature at which water changes from gas to liquid is called its boiling point.

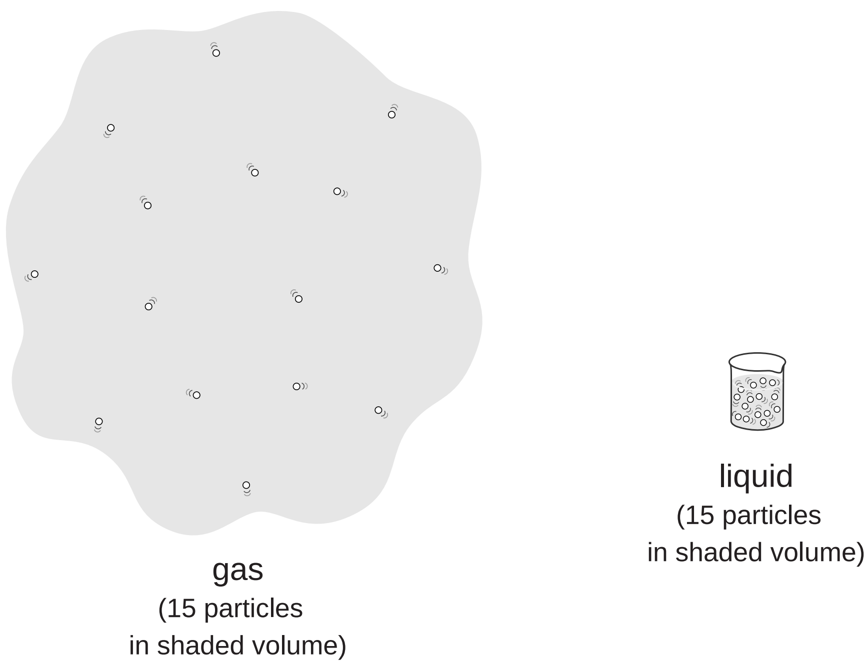

Figure 3: Differences in liquid and gaseous phases. Do 15 particles of liquid occupy the same volume as 15 particles of gas? What changes take place at the molecular level for you to observe what you see in this illustration?

Now imagine what happens to these particles when temperature decreases even more. What happens to their energy of motion? What happens to their motion?

Everyday experience tells you the answer. A solid forms. The temperature at which a solid forms is called the freezing point (also called the melting point when the temperature is rising and a liquid forms from the solid phase). At the freezing point, energy of motion decreases enough to allow particle attraction to take over. Particles lock in place and can only vibrate in one location. That is, the particles still move, but not very much. Solids keep their shape, while liquids and gases take the shape of their containers.

Now, imagine water in its three phases: as a gas in the atmosphere, as a liquid in a lake, and as ice covering that same lake in the winter. What's different about water molecules in these three phases of matter? Does water have different types of molecules in each phase? No, the molecules are the same. Let's think about the molecules and how they behave in each phase.

You know that the formula for water is H_2O. One molecule of water is made up of two hydrogen atoms and one oxygen atom. Each hydrogen atom bonds to the oxygen atom. As shown in Figure 4, water is a V-shaped molecule. Sometimes water is called the Mickey Mouse molecule. Can you see why?

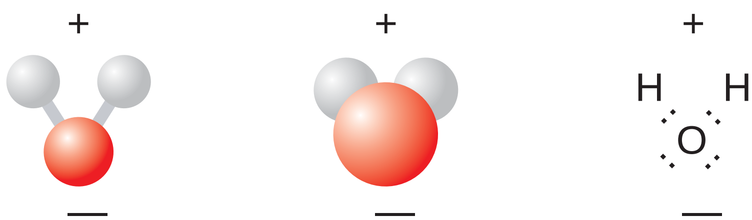

Figure 4: Dimensional representations of a water molecule. Water molecules remain the same in each phase of matter. Only the distance between molecules and the energy of motion changes.

Water molecules are the same in each phase. However, interactions between the molecules are different. Water molecules in the gas phase move fast and are too far apart to experience much attraction. When these molecules slow down enough, the distance between them decreases. That's when they are close enough for attractions between molecules to hold water molecules together, and they form a liquid. These attractions are called intermolecular attractions.

Intermolecular Attractions

Water molecules in the liquid phase form loose groups of four to eight molecules. As water cools to form ice, the molecules arrange themselves in an organized structure arranged in hexagons. Water molecules in the solid structure are actually farther apart than they are in their liquid phase. The more links there are, the less fluid the water becomes. As the water becomes less fluid, it becomes ice! Figure 5 represents the structure of liquid water and ice at the molecular scale.

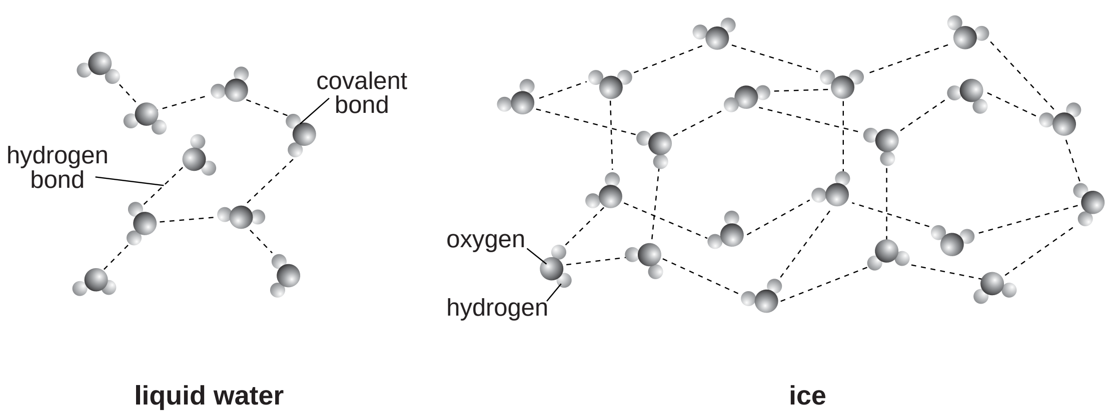

Figure 5: Representations of liquid and solid water at the molecular scale. The intermolecular attractions between water molecules are shown as dotted lines.

It's Just a Phase, But It Matters
The water we drink is a liquid at room temperature. But the oxygen we breathe is a gas at the same temperature, and the salt we eat is a solid. Would we survive if these essential substances were a different phase of matter? Imagine breathing liquid oxygen! Try to picture drinking solid water.

Life on Earth is possible, in part, due to the phases of matter in which water and other substances exist. Knowing about the factors that make different phases helps you understand your everyday world. And understanding your world makes life a lot more interesting.

Process and Procedure—continued

3. Read the following paragraphs to learn one way that scientists use models to understand matter.

   Everyday objects are easy to see. That's one reason we understand what they are. A bottle of milk or a dollar bill are objects that don't need an explanation. But some things are difficult to understand because we cannot see them easily. The stars in the sky can look like they are right next to each other from our view on Earth, but they are really trillions of miles apart, at very different distances from us.

   Scientists try to picture things they cannot see. It helps them explain their experiences. Often these "pictures" are called models. All models substitute easy to see or understand objects for things that are difficult or impossible to see or understand. Scientists develop and use many types of models to get a better understanding of things they cannot see directly in nature.

   Think about the stars mentioned earlier. How could you model the arrangement of stars to determine how they are positioned in three dimensions?

   Scientists might use computers to model how they think stars move in space. Computer models make it possible to try different ideas about how stars may actually be arranged in space. They can then see if the way the stars in the model move matches how the same stars move when they are observed. Models are important tools in science.

   What other models do you know about? In the next step, your teacher will help you and your classmates model what you cannot see within a substance when it is in the different phases: solid, liquid, and gas.

4. Your teacher will lead you through a modeling activity. Record the important ideas of your activity and discussion in your science notebook. Label your notes, *Model Activity Notes*.

5. On your own, copy the T-table in Figure 6, and write your answers in your science notebook.

This T-table helps you match what you did in the model activity with what happens in nature at the molecular level. You will use this information to form your own picture of how real particles behave.

Molecular model	How was this molecular model represented in the classroom model we just performed?
one particle (or molecule) of a pure substance	
all the particles (or molecules) in a sample of pure substance	
distance between the particles (or molecules) in a pure substance	
particles (or molecules) in the solid phase of matter such as ice (or wax before the wick is lit)	
particles (or molecules) in the liquid phase of matter such as water (or wax around the lit wick)	
particles (or molecules) in the gas phase of matter such as steam (or wax in the smoke that can be re-lighted); smoke particles are solid and do not ignite	
particles (or molecules) are in constant random motion, regardless of the phases of matter	

Figure 6: Model features T-table. This table helps you organize your thoughts. Think of how each aspect of the model activity represented each feature of phases of matter. Match your thinking with the correct feature in the table above.

6. Share the contents of your T-table with one team member. Take turns reading each cell in your table aloud. Listen carefully as your teammate reads his or her table.

Reflect and Connect

Answer each question in your notebook on your own. Then check your answers as instructed by your teacher. Make revisions to your answers based on what you learn by checking your answers.

1. In which phase of matter do particles have more motion? Explain how you know, based on what you have seen and learned in these lessons.

2. How does an increase in temperature (the energy of motion) for a constant number of particles in a gas affect the space between particles? Explain this relationship by completing the following statement appropriately:

If the energy of motion of the particles in a gas increases, then the distance between particles

____________________ because ____

____.

Now, answer this question another way—by sketching a graph. Copy the axes in Figure 7 into your science notebook and graph the relationship. The graph will show the relationship between energy of motion and distance between particles for a gas.

Sketched graphs need labeled axes, but no numbers.

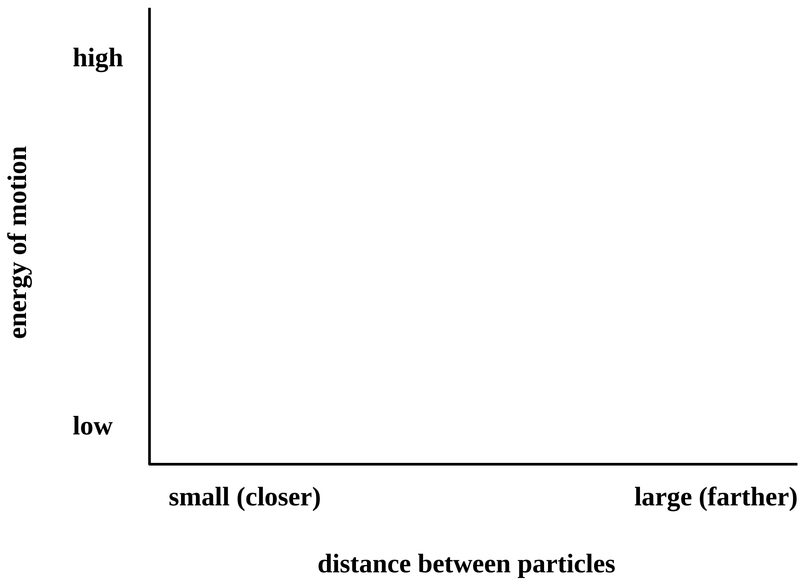

Figure 7: Relationship between energy of motion and distance between particles. How are distance between particles and energy of motion related? How does a graph show this relationship?

3. Answer the following question with a sketch and caption. In which phase of matter do attractions between particles affect motion the most? Explain why.

Elaborate
Super Model

You learned in the Explain activity how to model the microscopic particles that make up solids, liquids, and gases. But did the one-student-one-particle model really explain the macroscopic behavior of matter? To find out, you need to apply what you know from the model to what you know from reading the science content in *Water Works!* If there is a good match, then the model is an effective and useful way to explain phases of matter.

In this Elaborate activity, you and teammates will revisit your one-student-one-particle model. You will compare features of the model to scientific knowledge you learned from reading *Water Works!*

Process and Procedure

1. Check your understanding of phases of matter and models by helping your teacher complete a Venn diagram. Record the Venn diagram in your notebook.

   A Venn diagram is a figure made of overlapping circles that helps you represent similarities and differences. Use 3 overlapping circles, one each for solid, liquid, and gas. Include macroscopic and molecular information.

2. Revise your T-table from Step 5 the Explain activity, using the Venn diagram and your discussion as a guide to help you.

   Remember, scientists adjust their thinking based on new information. The T-table represents your most up-to-date model of invisible particles (or molecules) in the solid, liquid, and gas phases of matter.

3. Make and complete your own graphic organizer like the table below (figure 8). Give evidence for each statement you place in your organizer. The first row is completed as an example.

   Scientists verify their results. This can be done by matching what they did with facts they obtain in a well-accepted reading. This T-table helps you verify your results.

Model feature	How does this feature agree with the *Water Works!* reading? Why?
When molecules slow down, they get closer together.	The energy of motion decreases. They don't bounce as far apart. That results in less distance between particles.
add more rows to this table as you think about each feature of the model	

Figure 8: Model feature comparison with *Water Works!* reading. Use this table to evaluate the model you acted out with your class.

Reflect and Connect
Answer the question in your notebook on your own. Then check your answer as instructed by your teacher. Make revisions to your answer based on what you learn by checking your answer.

1. Think about a bottle of perfume. You stand at one end of a large room and your friend opens the bottle while standing at the opposite end of the room. She doesn't blow on the opened top. Create a model to explain, at the molecular level, why you smell the perfume after several minutes. Sketch your model and include highlight comments and a caption that explains the model.

Evaluate
Back to the Candle

You have built on prior knowledge to deepen and widen your understanding about phases of matter. That new understanding depends on linking evidence to explanations. The evidence has come from your five senses, scientific readings, and models. The explanations you construct result from talking with classmates, thinking on your own, and consulting with your teacher. Now it is time to demonstrate what you have learned about phases of matter.

In *Back to the Candle*, you will show what you know about the phases of matter in a burning candle. You will use the experiences from the previous activities to identify, describe, and explain each phase of matter in a burning candle. You will do this from both macroscopic and molecular view points.

Process and Procedure

1. Review what you learned in the Engage, Explore, Explain, and Elaborate activities about the following concepts:

   - macroscopic characteristics of solids, liquids, and gases
   - intermolecular attraction
   - molecular motion
   - models
   - temperature
   - distance between particles
   - energy of molecular motion

2. On a new page in your science notebook, demonstrate what you know about each of the concepts listed in Step 1 as they relate to a burning candle. Your description must include three ways of representing what you know.

   - **Sketches.** Your candle drawing needs to offer connections between the macroscopic and molecular views of matter.
   - **Graphic Organizers.** One or more graphic organizers need to display key knowledge in a way that promotes understanding.
   - **Caption.** Place a caption under your sketches that explains the important concepts being illustrated in the sketch. Captions should be written in paragraph form.

Reflect and Connect

Read the question carefully before you answer it. Use the key understandings you learned in the previous activity.

1. Complete the following table (figure 9) in your science notebook to demonstrate your understanding of states of matter. Your answers will show similarities and differences between water and wax in three phases of matter.

	Solid	**Liquid**	**Gas**
Example from water			
Example from wax			
Temperature (low, medium, high)			
Average distance between molecules			
Strength of intermolecular attraction			
Amount of energy of motion			
Speed of molecules			

Figure 9: States of matter. This graphic organizer will help you keep track of a lot of information. Complete the table using your science notebook as a source of information.