Ice Cubes in a Bag

You are having an argument with your friend about what happens to the mass when matter changes from one form to another. To prove your idea, you put three ice cubes in a sealed bag and record the mass of the ice in the bag. You let the ice cubes melt completely. Ten minutes later you record the mass of the water in the bag. Which of the following best describes the result? Circle your prediction.

A  The mass of the water in the bag will be less than the mass of the ice in the bag.

B  The mass of the water in the bag will be more than the mass of the ice in the bag.

C  The mass of the water in the bag will be the same as the mass of the ice cubes in the bag.

Describe your thinking. Provide an explanation for your answer.
Explanation

The best response is C—the mass would be the same. Mass is a measure of the amount of matter in a substance. When water changes from one state to another, the number of molecules of water does not change; therefore, the amount of matter or mass does not change. This rule applies to changes between liquids and gases as well as solids and liquids. A change in state is a change in the average motion and arrangement of the molecules, not the number of molecules or their mass. Also, the sealed bag implies a closed system (even though plastic bags are semipermeable). If a system is closed, then no new matter can get into the bag and nothing can get out. Therefore, the total mass remains the same since nothing is added or subtracted. Conservation of matter is a physical principle, applied to ordinary physical and chemical changes, that states that matter cannot be created or destroyed. This principle is used to explain a variety of chemical, biological, and geologic changes.
Lesson Focus

1. What happens to a molecule of a substance when heat is added to it?

2. How does molecular motion differ in solid, liquid, and gas.

3. How does the shape and volume of a substance change from a solid to a liquid to a gas?
States of Matter

Think about the differences between, for example, a rock, milk, and air. The shape of a rock does not change unless you cut or smash it. Milk takes on the shape of its container, and if you pour it on the floor it will spread out to form a puddle. Air spreads out even more than milk does. And it keeps spreading out in all directions.

Rocks, milk, and air represent different physical forms in which a substance can exist: a rock is a solid, milk is a liquid, and air is a gas. Solids, liquids, and gases are three states of matter. The chart below lists the defining features of each state.

<table>
<thead>
<tr>
<th>State of Matter</th>
<th>Defining Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid</td>
<td>• keeps its shape and volume</td>
</tr>
<tr>
<td>Liquid</td>
<td>• takes on the shape of its container</td>
</tr>
<tr>
<td></td>
<td>• keeps the same volume, in a container or not</td>
</tr>
<tr>
<td></td>
<td>• can flow</td>
</tr>
<tr>
<td>Gas</td>
<td>• takes on the shape and volume of its container</td>
</tr>
<tr>
<td></td>
<td>• can flow (through a room, for example)</td>
</tr>
</tbody>
</table>

The three states of matter are also known as the phases of matter.
A fourth state of matter is called a plasma. Like a gas, a plasma does not have a definite shape or volume. Plasmas only exist at very high temperatures. Stars, including the sun, are made of matter in a plasma state.

But why are solids solid, liquids liquidy, and gases gassy? To answer this question, you first need to understand three things:

- All matter is made up of tiny particles called atoms and molecules.
- These particles attract each other; the greater the attraction, the closer the particles get.
- These particles are constantly in motion and bumping into each other. The temperature of a substance is related to the speed at which its particles move.
The state of a substance depends on how fast its particles move and how strong the attraction is between the particles.

**Solid** The particles of a substance in its solid state vibrate in place, but the vibration isn’t great enough to overcome the attraction between the particles and cause them to separate. As a result, the forces between the particles cause them to lock together.

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**Students Model and Draw**

<table>
<thead>
<tr>
<th>Attraction</th>
<th>Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attraction</td>
<td>Atoms or molecules are very attracted to one another.</td>
</tr>
<tr>
<td>Movement</td>
<td>Vibrate but do not move past one another.</td>
</tr>
<tr>
<td>Volume and Shape</td>
<td>Have a definite volume and a definite shape.</td>
</tr>
</tbody>
</table>

**Particles of a solid**
**Liquid** The particles of a substance move even faster when the substance is in a liquid state. As a result, the particles in a liquid can overcome some of the attraction between them. So, unlike the particles in a solid, which are locked together, the particles in a liquid can flow around and over each other. If you spill a glass of water on the floor, for example, the water molecules stick together enough to make a puddle, but not enough to keep the shape the water had when it was in the glass.

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**Students Model and Draw**

<table>
<thead>
<tr>
<th>Attraction</th>
<th>Liquids</th>
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<tr>
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</table>

<table>
<thead>
<tr>
<th>Movement</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibrate but are able to move past one another.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume and Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have a definite volume, but does not have a definite shape.</td>
</tr>
</tbody>
</table>

**Particles of a liquid**
**Students Model and Draw**

<table>
<thead>
<tr>
<th>Attractions</th>
<th>Gases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Atoms or molecules are barely attracted to one another.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Movement</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vibrate and move freely past each other.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume and Shape</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Does not have a definite volume or a definite shape.</td>
</tr>
</tbody>
</table>

Particles of a gas 🌊

**Gas**

The particles of a substance move fastest when the substance is in a gaseous state—so fast that they are able to overcome the attraction between them and separate from each other entirely. That’s why a gas will spread out in all directions, filling up a balloon, a room, or the atmosphere.
The state of a substance depends on how fast its particles move and how strong the attraction is between the particles.

**Solid** The particles of a substance in its solid state vibrate in place, but the vibration isn’t great enough to overcome the attraction between the particles and cause them to separate. As a result, the forces between the particles cause them to lock together.

**Liquid** The particles of a substance move even faster when the substance is in a liquid state. As a result, the particles in a liquid can overcome some of the attraction between them. So, unlike the particles in a solid, which are locked together, the particles in a liquid can flow around and over each other. If you spill a glass of water on the floor, for example, the water molecules stick together enough to make a puddle, but not enough to keep the shape the water had when it was in the glass.

**Gas** The particles of a substance move fastest when the substance is in a gaseous state—so fast that they are able to overcome the attraction between them and separate from each other entirely. That’s why a gas will spread out in all directions, filling up a balloon, a room, or the atmosphere.

*Summary*
Summary
Dear Tim and Moby,

What makes a gas a gas or a liquid a liquid?

States of Matter Video
Match the object on the left with the configuration of its molecules on the right.
TRUE OR FALSE

Determine if the statement is true or false. If false, replace the word(s) in bold with the correct word(s) on the line. If true, write ‘true’ on the line.

1. ......................... All matter is made up of tiny particles called ATOMS.

2. ......................... There is a CHEMICAL difference between the gaseous and liquid state of the same substance.

3. ......................... Liquids have a fixed TEMPERATURE, but no fixed shape.

4. ......................... Molecules of ice have less MASS than molecules of water.

5. ......................... A PLASMA is a gas with an electrical charge.
What is matter? Choose the best answer.

A. Anything that is solid
B. Anything that takes up space
C. Anything that has a fixed volume
D. Anything that can be seen
2 In what way are liquids different from solids?

A Liquid molecules are lighter than solid molecules

B Liquids are made of atoms; solids are made of molecules

C Liquids don't have a fixed shape; solids do

D Liquids are always denser than solids
3. What happens to the chemical structure of water when it changes state?

A. Water molecules break apart to form individual atoms

B. Water molecules harden into ice molecules

C. Water molecules melt into gas molecules

D. Nothing happens to the chemical structure
4. What will happen if you keep increasing both the pressure and temperature of a liquid?

A. It will boil
B. It will transpire
C. It will melt
D. It will solidify
5 What do lightning and stars have in common?

A. Both have no electrical charge
B. Both contain plasma
C. Both have a fixed volume
D. Both contain all three states of matter
Water's chemical formula is "H2O." What does this mean?

A. Water is composed of hydrogen molecules and oxygen molecules
B. A gram of water contains 20 hydrogen atoms
C. Each water molecule contains two hydrogen atoms and one oxygen atom
D. Water molecules cannot be split into smaller pieces
7. What is the basic shape of a liquid?

A. A sphere
B. The same shape as a gas, only rounder
C. A cube
D. Whatever the shape of its container is
8 How can you remove energy from matter?

A By increasing its volume
B By lowering its temperature
C By increasing its pressure
D By boiling it
Gases have a tendency to expand. What's the best synonym for "expand?"

A  Collide
B  Spread out
C  Shrink
D  Boil
10 Which of the following states of matter has a definite volume?

A. liquids and gases only
B. solids only
C. liquids only
D. solids and liquids only
11. Which ending completes the following sentence: Oxygen is a gas that has _______.

A. definite shape and volume  
B. definite shape, but no definite volume  
C. no definite shape or volume  
D. no definite shape, but has definite volume
Match the object on the left with the configuration of its molecules on the right.

12
13
14

A.
B.
C.
Exit Slip- You can only leave the room if you can answer these questions!!

1. What happens to a molecule of a substance when heat is added to it?

2. How does molecular motion differ in solid, liquid, and gas.

3. How does the shape and volume of a substance change from a solid to a liquid to a gas?
Changing States of Matter

Water is a substance that can be found in three states: solid ice, liquid water, and water vapor (a gas). You know from experience that water can change from one state to another. The same is true of most other substances as well.

Melting: From Solid to Liquid
If you put an ice cube in a cup and set it on the counter, the ice will melt. Melting is the change from a solid state to a liquid state. The temperature at which a solid melts is called its melting point. The melting point of ice is 0°C.

What causes a solid to melt? If you heat a solid, the particles in that solid will begin to move faster. If you keep heating the solid, eventually the motion of the particles will become great enough to overcome the attraction that locks the particles together. When that happens, the solid becomes a liquid.
Freezing: From Liquid to Solid
If you place a cup of water in the freezer, the water will turn to solid ice. **Freezing** is the change from a liquid state to a solid state. The temperature at which a liquid freezes is called its **freezing point**. Because freezing is the reverse of melting, a substance will freeze at the same temperature at which it melts. So, the freezing point of water is also 0°C.

What causes a liquid to freeze? If you cool a liquid, the liquid’s particles will begin to slow down. If you keep cooling the liquid, eventually the motion of the particles will slow to the point where they cannot overcome the attraction between them. At some point, the particles will lock together and the liquid becomes a solid.
Vaporization: From Liquid to Gas

If you place a pan of water on a hot stove, eventually the water will begin to boil. Water vapor (or steam) is produced during vaporization, the change from a liquid state to a gaseous state. Boiling causes the liquid water to vaporize. The boiling point of water is 100°C.
The same process that causes a solid to melt causes a liquid to vaporize. As a substance is heated, its particles begin to move faster and faster. During vaporization, the fastest particles are able to overcome the attraction of the particles around them and break free completely. These escaped particles become a gas—water vapor.

A pan of water left on the counter top will evaporate over several days. Evaporation is vaporization that occurs at the surface of a liquid. Evaporation can take place at temperatures below the liquid's boiling point.
Condensation: From Gas to Liquid

Condensation is the change from a gaseous state to a liquid state. The temperature at which a gas condenses is called its condensation point. At sea level, the condensation point of water vapor is 100°C—the same as the boiling point of water. That is because condensation is the reverse of vaporization. Water vapor can exist in the air at temperatures below 100°C. If you pour cold juice into a glass on a humid summer day, you will begin to notice beads of water forming on the outside of the glass. What you observe is water vapor from the air around the glass that has condensed on the glass.

The same process that causes a liquid to freeze causes a vapor to condense. As a vapor cools, its particles begin to slow down. Condensation takes place when the particles slow down so much that they cannot overcome the attraction of the particles around them. When this happens, they clump together to form a liquid.
Chemical and Physical Properties
**Background:** Keeping the difference between physical and chemical properties as well as changes can be a challenge. This worksheet will help you do this. First, use the book to define the following terms.

<table>
<thead>
<tr>
<th>VOCABULARY WORD</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Property</td>
<td>Characteristics of matter that can be seen through direct observation such as density, melting point, and boiling point</td>
</tr>
<tr>
<td>Physical Change</td>
<td>Change in which the identity of the substance does NOT change</td>
</tr>
<tr>
<td>Chemical Property</td>
<td>Characteristic of matter that can only be observed when one substance changes into a different substance, such as iron into rust</td>
</tr>
<tr>
<td>Chemical Change</td>
<td>Transforms one type of matter into another kind, which may have different properties.</td>
</tr>
<tr>
<td>Physical Property</td>
<td>Definition</td>
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</table>
PHYSICAL CHANGES
Physical changes in matter

A physical change is a change in how matter looks, but not the kind of matter it is.

- Tear
- Cut
- Folded
- Written
- Liquid
- Solid
- Gas
- Mixture
- Solution
<table>
<thead>
<tr>
<th>Chemical Property</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>• flammability</td>
<td></td>
</tr>
<tr>
<td>• Ability to rust</td>
<td></td>
</tr>
<tr>
<td>• Reactivity with vinegar</td>
<td></td>
</tr>
</tbody>
</table>

Erase to reveal if you got it right!
Chemical changes in matter

New Matter is formed.

- Burning
- Rusting
- Cooking
Is this a solid, a liquid, or a gas?

Can you find more than one type of matter in any of the pictures?
Is this a physical change or a chemical change? Can you find more than one physical or chemical change in the pictures?
**Part Two:** Physical or Chemical Change? Indicate with a 'P' or a 'C' which type of change is taking place.

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 1. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | glass breaking
| 2. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | hammering wood together
| 3. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | a rusting bicycle
| 4. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | melting butter
| 5. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | separate sand from gravel
| 6. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | bleaching your hair
| 7. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | frying an egg
| 8. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | squeeze oranges for juice
| 9. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | melting ice
| 10. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | mixing salt and water
| 11. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | mixing oil and water
| 12. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | water evaporating
| 13. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | cutting grass
| 14. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | burning leaves
| 15. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | fireworks exploding
| 16. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | cutting your hair
| 17. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | crushing a can
| 18. |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   | boiling water