

Heat and Changes in Matter

3-4 The student will demonstrate an understanding of the changes in matter that are caused by heat.

3-4.1 Classify different forms of matter (including solids, liquids, and gases) according to their observable and measurable properties.

Taxonomy level: 2.3-A, B Understand Factual and Conceptual Knowledge

Previous/Future knowledge: In 2nd grade (2-4.1), students were introduced to the concept of liquids and solids and their properties. Students have not been introduced to the properties of gases in previous grades. Students will compare the physical properties of the states of matter in 5th grade (5-4.2).

It is essential for students to know that matter is anything that has mass and takes up space.

Mass

- *Mass* is how much matter is in an object.
- Mass can be measured using a *balance* with known masses compared to the unknown mass being measured.
- An object with a large mass feels heavier than an object with a smaller mass.

Volume

- *Volume* is the amount of space an object takes up.
- Volume of a liquid can be measured with a beaker, graduated cylinder or graduated syringe.
- An object that takes up more space has a greater volume.

Properties of matter are characteristics that can be used to describe matter.

Observable (<i>using senses</i>) properties	Measurable (<i>using tools</i>) properties
<i>(Using sense of sight):</i> color, size, shape, shininess or luster	<i>(Using balance):</i> mass
<i>(Using sense of touch):</i> texture or relative hotness or coldness	<i>(Using graduated cylinder or syringe, or beaker):</i> volume
<i>(Using sense of smell):</i> odor present or not	<i>(Using thermometer):</i> temperature
	<i>(Using ruler):</i> length

Matter is classified into the following forms based on observable and measurable properties:

- *Solids* have a definite size and shape, that is, the size and shape do not change.
- *Liquids* have a definite volume, but they take the shape of their containers.
- *Gases* do not have a definite shape or volume. Gases take the shape and size of their container.

It is not essential for students to calculate the volume of a solid object or the volume of a gas.

Assessment Guidelines:

The objective of this indicator is to *classify* solids, liquids, and gases according to their observable and measurable properties; therefore, the primary focus of assessment should be to group materials into categories of solids, liquids, or gases based on their observable and measurable properties. However, appropriate assessments should also require students to *infer* from information about materials with their properties described, whether the materials are

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solids, liquids, or gases; *compare* various materials to determine which are solids, liquids, or gases; *identify* a material with properties described as a solid, liquid, or gas; or *summarize* the properties of solids, liquids, and gases.

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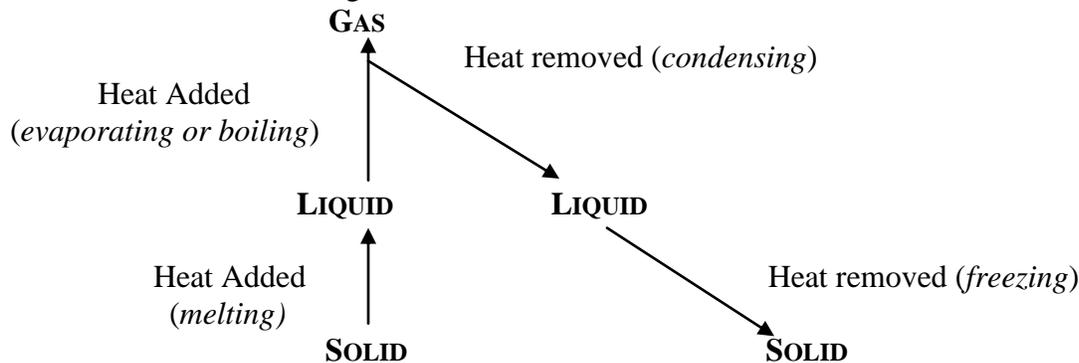
3-4 The student will demonstrate an understanding of the changes in matter that are caused by heat.

3-4.2 Explain how water and other substances change from one state to another (including melting, freezing, condensing, boiling, and evaporating).

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: In 2nd grade (2-4.2), students exemplified matter changing from a solid to a liquid and from a liquid to a solid. Students have not been introduced to the terms for these changes or how heat is involved in previous grades. In 4th grade (4-4.1), students will summarize the processes of the water cycle, including evaporation and condensation. In 5th grade (5-4.2), students will compare the physical properties of the states of matter (including volume, shape, and the movement and spacing of particles).

It is essential for students to know that water and other substances can change from one state to another with either heat is added or removed. The diagram below shows the relationship between heat and the changes of state:



Melting

- *Melting* occurs when a solid is heated enough to change to a liquid.
- When solid ice *melts*, it changes to liquid water.
- Ice *melts* at 0°C or 32°F.

Freezing

- *Freezing* occurs when a liquid cools enough (heat is removed) to form a solid.
- When liquid water freezes, it changes to solid ice.
- Water freezes at 0°C or 32°F.
- Water will expand when it freezes; other substances contract.

Evaporation

- *Evaporation* occurs when liquids change to gases rather slowly at the surface of the liquid as heat is added from their surroundings.

NOTE TO TEACHER: Evaporation occurs at any temperature.

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Boiling

- *Boiling* also is the change from a liquid to a *gas* but faster with bubbles of gas forming in the liquid at a given temperature because a lot heat is being added from a source.
- Water boils at 100°C or 212°F. When substances are heated, they will expand and take up more space.

Condensing

- Condensing occurs when a gas is cooled enough (heat is removed) to form a liquid.
- For example, condensation occurs, when liquid water is visible on the outside of a glass of ice water.
- The water vapor or gas in the air is cooled when it contacts the cold surface of the glass.
- Another example of condensation is when liquid water droplets form on the cool surface of the mirror in the bathroom from hot water vapor produced by the shower.
- The water vapor in the air condenses on the cool mirror.

It is not essential for students to know the temperatures at which melting, boiling, or freezing occur in other substances besides water.

Assessment Guidelines:

The objective of this indicator is to *explain* how water and other substances change from one state to another; therefore, the primary focus of assessment should be to construct a cause-and-effect model to show how heat causes melting, evaporating, and boiling and how cooling (removing heat) causes condensing and freezing. However, appropriate assessments should also require students to *summarize* the processes by which substances change from one state to another by being either heated or cooled; *interpret* a diagram of changing states of matter with heating and cooling; *compare* various matter changing states by being heated or being cooled; or *identify* the processes by which matter changes from one state to another.

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3-4.3 Explain how heat moves easily from one object to another through direct contact in some materials (called conductors) and not so easily through other materials (called insulators).

Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: The concept of heat moving from one object to another is new material for this grade level. Students will further develop the concept of forms of energy (light and electricity) in 4th grade (4-5.2 and 4-5.5).

It is essential for students to know that heat makes things warmer. Some materials allow heat to move through them easily and others do not as follows:

Conductors

- Some materials allow heat to move easily through them and from one object to another through direct contact.
- These materials are called *conductors*.
- If a metal spoon, for example, is put in hot water, it will become warmer.
- Metal objects are good *conductors* of heat, and they get warmer.

Insulators

- Other materials do not allow heat to move easily through them and are called *insulators*.
- If wooden and plastic spoons are put in hot water, for example, they do not become warmer.
- These materials do not allow heat to move easily through them.
- Plastic and wood materials are *insulators*, and they do not get warmer.

It is not essential for students to know that heat is a form of energy that causes the particles in matter to move faster, or that it is also transferred by convection or radiation.

Assessment Guidelines:

The objective of this indicator is to *explain* that heat either moves easily in some materials called conductors or not so easily in other materials called insulators; therefore, the primary focus of assessment should be to construct a cause-and-effect model of heat moving easily in a conductor or not so easily in an insulator. However, appropriate assessments should also require students to *illustrate* or *exemplify* insulators and conductors; *classify* materials as either insulators or conductors; *compare* insulators and conductors; or *identify* materials as either insulators or conductors.

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3-4.4 Identify sources of heat and exemplify ways that heat can be produced (including rubbing, burning, and using electricity).

Taxonomy level: 1.1-A Remember Factual and
2.2-B Understand Conceptual Knowledge

Previous/Future knowledge: The concept of heat or how it can be produced is new material for this grade level. Students will further develop the concept of sources of heat energy in 6th grade (6-5.1).

It is essential for students to know that sources of heat produce heat energy and make things warmer, for example, fires, stoves, toasters, ovens, the Sun, light bulbs, engines, animals, and other common objects in their environment. They should also identify the following ways that heat can be produced:

Rubbing

- When objects are *rubbed* together, heat is produced.
- For example, when hands *are rubbed* together, they get warmer on a cold day.

Burning

- When materials are *burned* in a fire, heat can be produced.
- For example, when wood or candles are burned, they produce heat.

Using electricity

- When *electricity* is used, heat can be produced.
- For example, when electricity is used in light bulbs, heaters, stoves, toasters, or ovens, things get warmer.

It is not essential for students to know ways to extinguish fires or what materials are necessary for fires to start, or for students to know that particles of matter move faster as a result of heat production.

Assessment Guidelines:

One objective of this indicator is to *identify* sources of heat; therefore, the primary focus of assessment should be to recognize an object or material that produces and gives off heat.

Another objective is to *exemplify* ways heat can be produced, therefore, the primary focus of that objective is to give examples of producing heat by rubbing, burning, or using electricity. However, appropriate assessments should also require students to *illustrate* heat being produced by the processes of rubbing, burning, and using electricity.