Name _____ Class _____ Date _____

SECTION 1 Temperature

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- How are temperature and kinetic energy related?
- How is temperature measured?
- What is thermal expansion?

National Science Education Standards

PS 3a, 3b

What Is Temperature?

You may think of temperature as how hot or cold something is. But using the words *hot* and *cold* can be confusing. Pretend that you are outside on a hot day. If you step onto a porch with a fan blowing, you might think it feels cool. Then, your friend enters the porch from an air-conditioned house. She thinks the porch is warm!

Using the words cool and warm to describe the porch is confusing. Measuring the temperature on the porch tells you exactly how hot or cold it is. The **temperature** tells you the average kinetic energy of the particles in an object. ☑

STUDY TIP

Describe Describe how temperature affects the average kinetic energy and thermal expansion. Give several examples of thermal expansion.

READING CHECK

1. Identify What is used to tell how hot or cold something is?

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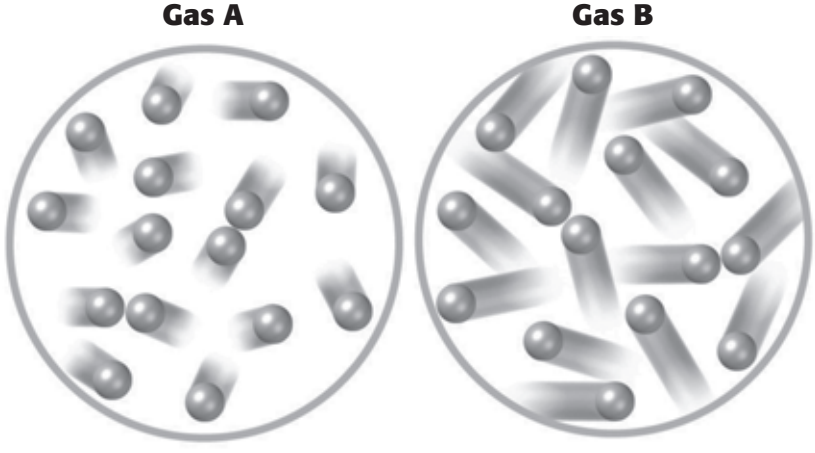
TEMPERATURE AND KINETIC ENERGY

All matter is made of atoms or molecules that are always moving. The particles that are moving have kinetic energy. The faster they move, the more kinetic energy they have. Look at the figure below. The more kinetic energy the particles have, the higher the temperature is.



The gas particles on the right have higher kinetic energy than those on the left.

TAKE A LOOK

2. Identify Which gas shows particles at the higher temperature?

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AVERAGE KINETIC ENERGY

The particles that make up matter are always moving in different directions and speeds. This movement is random. Since the particles move at different speeds, each particle has its own kinetic energy. The temperature of a substance is a measure of the *average kinetic energy* of all the particles in a substance. A high temperature means more of the particles in the object are moving fast rather than slow.

The temperature of a substance does not depend on how much of it you have. Look at the figure below. A pot of tea and a cup of tea each have a different amount of tea. Their atoms have the same average kinetic energy. There may be more tea in the teapot than in the cup, but they are at the same temperature.

STANDARDS CHECK

PS 3a Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways.

3. Identify The temperature of a substance is a measure of what kind of energy?

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Critical Thinking

4. Infer As the tea in the cup cools, what happens to the average kinetic energy of the particles in the tea? What happens to the motion of the particles in the tea?

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There is more tea in the teapot than in the cup. But the temperature of the tea in the cup is the same as the temperature of the tea in the teapot.

How Is Temperature Measured?

How do you measure the temperature of a cup of hot chocolate? If you took a sip of it, you would not be able to measure the temperature very well. The best way is to use a thermometer.

USING A THERMOMETER

Many thermometers are thin glass tubes filled with a liquid. Mercury and alcohol are often used in thermometers because they are a liquid over a wide range of temperatures. They also expand at a constant rate.

Thermometers that use liquids can measure temperature because of thermal expansion. **Thermal expansion** is the increase in the volume of a substance when the temperature of the substance increases. When a substance's temperature increases, its particles move faster and farther away from each other. There is more space between the particles, so the substance expands. ☑

If you look at the figure below, all three thermometers are at the same temperature. The alcohol in each thermometer has expanded the same amount. The number reading for each thermometer is different because a different temperature scale is used for each one.

READING CHECK

5. Describe What is thermal expansion?

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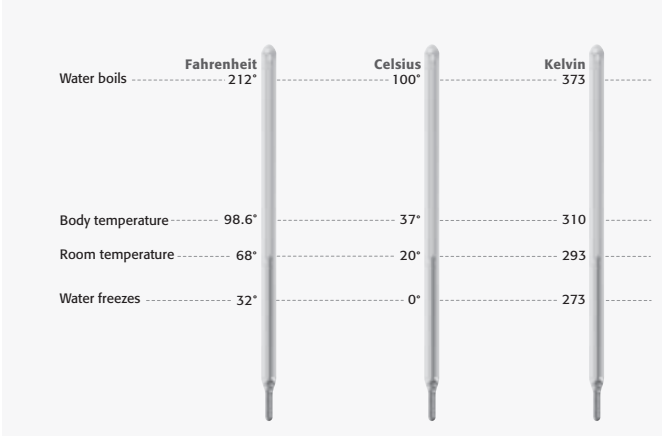
Three Temperature Scales



TEMPERATURE SCALES

There are three different temperature scales that are often used. They are the Fahrenheit scale, the Celsius scale, and the Kelvin scale. When you hear a weather report, you hear the temperature given in degrees Fahrenheit (°F). Scientists often use the Celsius scale. The Kelvin (or absolute) scale is the official SI temperature scale. The Kelvin scale has units called kelvins (K). The Kelvin scale does not use degrees, so 25 K is 25 kelvins. ☑

The lowest temperature on the Kelvin scale is 0 K. This is called **absolute zero**. Absolute zero (−459°F) is the temperature at which all molecules stop moving. It is not possible to reach absolute zero because molecules are always moving.

READING CHECK

6. Identify Which temperature scale is the SI temperature scale?

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TEMPERATURE CONVERSION

For a given temperature, each temperature scale has a different number reading. For example, the freezing point of water is 32°F, 0°C, or 273 K. You can change from one scale to another using the equations in the table below.

Converting Between Temperature Units

To convert	Use the equation	Example
Celsius to Fahrenheit °C ⟶ °F	$F = \left(\frac{9}{5}C\right) + 32$	Change 45°C to degrees Fahrenheit.
Fahrenheit to Celsius °F ⟶ °C	$C = \frac{5}{9} \times (F - 32)$	Change 68°F to degrees Celsius.
Celsius to Kelvin °C ⟶ K	$K = C + 273$	Change 45°C to Kelvins.
Kelvin to Celsius K ⟶ °C	$C = K - 273$	Change 32 K to degrees Celsius.

Math Focus

7. Calculate In the last column of the table, calculate the temperature for the temperature scale given.

A change of one Kelvin is the same as a change of one Celsius degree. So a temperature change from 0°C to 1°C is the same as a change from 273 K to 274 K. However, a temperature change of 1°C is higher than a change of 1°F. It's almost two times as large.

What Are Other Examples of Thermal Expansion?

You have learned how thermal expansion is used in thermometers. Thermal expansion has many other uses. Sometimes it is harmful, but other times it is useful.

EXPANSION JOINTS ON HIGHWAYS

Have you ever gone across a bridge in a car? You may have felt bumps every few seconds. The car is going over small spaces called *expansion joints*. If the weather is really hot, the bridge can heat up and expand. When it expands, the bridge can break. Expansion joints separate parts of the bridge so they can expand and not break. ☑

READING CHECK

8. Describe What is the purpose of expansion joints in a bridge?

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BIMETALLIC STRIPS IN THERMOSTATS

Another example of thermal expansion happens in a *thermostat*, a device that controls the temperature in your home. The thermostat has a *bimetallic strip* with two different metals coiled together. The strip coils and uncoils as the temperature changes. ☑

Most thermostats have a tube of mercury that is moved by a bimetallic strip. The figure below shows how a mercury thermostat works. The mercury in a tube moves to touch or not touch electrical contacts. Electrical contacts are two pieces of metal that can touch to complete a circuit. This makes the electric circuit in the thermostat close or open. So the thermostat turns on and off the heater in your home.

READING CHECK

9. Explain What does the bimetallic strip do in a thermostat? Why?

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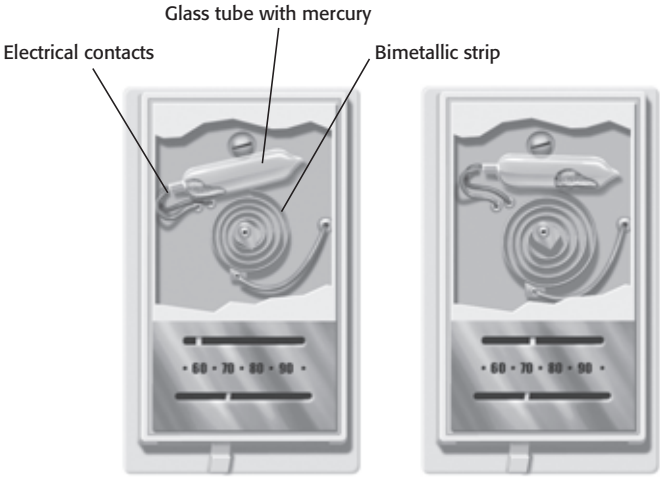
How a Thermostat Works



a When the room temperature is lower than the temperature setting, the bimetallic strip coils. This causes the glass tube above the strip to tilt. Mercury flows and closes the electrical circuit. The result is that the heater turns on.

b When the room temperature is higher than the temperature setting, the bimetallic strip uncoils. It becomes larger. This causes the glass tube above the strip to flatten out. The mercury moves away and opens the electrical circuit. The result is that the heater turns off.

TAKE A LOOK

10. Explain What happens to the mercury in a thermostat that results in the heater turning on?

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THERMAL EXPANSION IN HOT AIR BALLOONS

Thermal expansion is also used in hot air balloons. When air inside a balloon is heated, the air takes up more space. The air particles move faster because they have more kinetic energy. The gas expands to fill the volume of the balloon. The air inside the balloon is less dense than the air outside the balloon. So, the balloon goes up into the air because it is less dense than the air around it.

Name _____ Class _____ Date _____

Section 1 Review

NSES PS 3a, 3b

SECTION VOCABULARY

absolute zero the temperature at which molecular energy is at a minimum (0 K on the Kelvin scale or −273.16°C on the Celsius scale) **thermal expansion** an increase in the size of a substance in response to an increase in the temperature of the substance	**temperature** a measure of how hot (or cold) something is; specifically, a measure of the average kinetic energy of the particles in an object

1. **Compare** How is the temperature of an object related to its kinetic energy?

2. **Calculate** The thermometer outside your window reads 77°F. What is the same temperature on the Celsius scale? Show your work.

3. **Determine** You are doing a science experiment and watching the temperature change in Celsius degrees. If the temperature changes by 5°C, how does it change in Kelvins?

4. **Explain** How is the liquid in a thermometer used to measure temperature? Why are mercury and alcohol used in thermometers?

5. **Analyze** How is thermal expansion used to get a hot air balloon off of the ground?