THE BIG IDEA

When matter gets warmer, the atoms or molecules in the matter move faster.

All matter—solid, liquid, and gas—is composed of continually jiggling atoms or molecules. Because of this random motion, the atoms and molecules in matter have kinetic energy. The average kinetic energy of these individual particles causes an effect we can sense—warmth.

Whenever something becomes warmer, the kinetic energy of its atoms or molecules has increased. When the atoms or molecules in matter move faster, the matter gets warmer. Its atoms or molecules have more kinetic energy.

21.1 Temperature

The higher the temperature of a substance, the faster is the motion of its molecules.

21.1 Temperature

The quantity that tells how hot or cold something is compared with a standard is **temperature.**

Nearly all matter expands when its temperature increases and contracts when its temperature decreases.

A common thermometer measures temperature by showing the expansion and contraction of a liquid in a glass tube using a scale.

21.1 Temperature

Celsius Scale

The most widely used temperature scale is the **Celsius scale.**

- The number 0 is the temperature at which water freezes.
- The number 100 is the temperature at which water boils.

The gap between freezing and boiling is divided into 100 equal parts, called *degrees.*

21.1 Temperature

Fahrenheit Scale

The temperature scale used commonly in the United States is the **Fahrenheit scale.**

- The number 32 is the temperature at which water freezes.
- The number 212 is the temperature at which water boils.
- The Fahrenheit scale will become obsolete if and when the United States goes metric.

21.1 Temperature

Kelvin Scale

Scientific research uses the SI scale—the *Kelvin scale.*

- Degrees are the same size as the Celsius degree and are called “kelvins.”
- On the **Kelvin scale,** the number 0 is assigned to the lowest possible temperature—*absolute zero.*
- At **absolute zero** a substance has no kinetic energy to give up.
- Zero on the Kelvin scale corresponds to -273°C.

21.1 Temperature

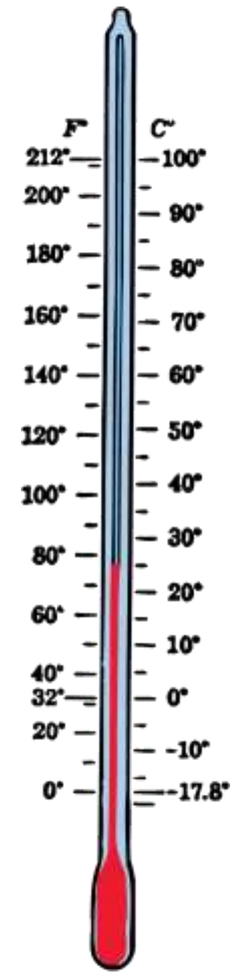
Scale Conversion

Arithmetic formulas can be used for converting from one temperature scale to another.

A conversion from Celsius to Fahrenheit, or vice versa, can be very closely approximated by simply reading the corresponding temperature from side-by-side scales.

21.1 Temperature

This thermometer measures temperature on both Fahrenheit and Celsius scales.



21.1 Temperature

Temperature and Kinetic Energy

Temperature is related to the random motions of the molecules in a substance.

In the simplest case of an ideal gas, temperature is proportional to the *average* kinetic energy of molecular translational motion.

21.1 Temperature

In solids and liquids, where molecules are more constrained and have potential energy, temperature is more complicated.

The warmth you feel when you touch a hot surface is the kinetic energy transferred by molecules in the surface to molecules in your fingers.

21.1 Temperature

Temperature is *not* a measure of the *total* kinetic energy of all the molecules in a substance.

Two liters of boiling water have twice as much kinetic energy as one liter.

The temperatures are the same because the average kinetic energy of molecules in each is the same.

21.1 Temperature

There is more molecular kinetic energy in the bucketful of warm water than in the small cupful of higher-temperature water.

21.1 Temperature

CONCEPT CHECK

What is the relationship between the temperature of a substance and the speed of its molecules?

21.2 Heat

When two substances of different temperatures are in thermal contact, heat flows from the higher-temperature substance into the lower-temperature substance.

21.2 Heat

If you touch a hot stove, energy enters your hand from the stove because the stove is warmer than your hand.

If you touch ice, energy passes from your hand into the colder ice.

The direction of spontaneous energy transfer is always from a warmer to a cooler substance.

The energy that transfers from one object to another because of a temperature difference between them is called **heat.**

21.2 Heat

It is common—but incorrect with physics types—to think that matter *contains* heat.

Matter contains energy but it does not contain heat.

Heat is energy *in transit,* moving from a body of higher temperature to one of lower temperature.

21.2 Heat

Once transferred, the energy ceases to be heat.

Previously, we call the energy resulting from heat flow *thermal energy,* to make clear its link to heat and temperature.

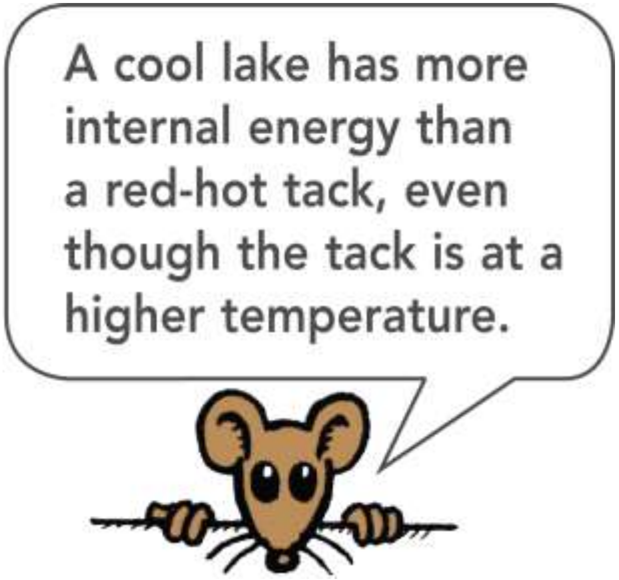
We will use the term that scientists prefer, *internal energy.*

When heat flows from one object or substance to another it is in contact with, the objects are said to be in **thermal contact.**

21.2 Heat

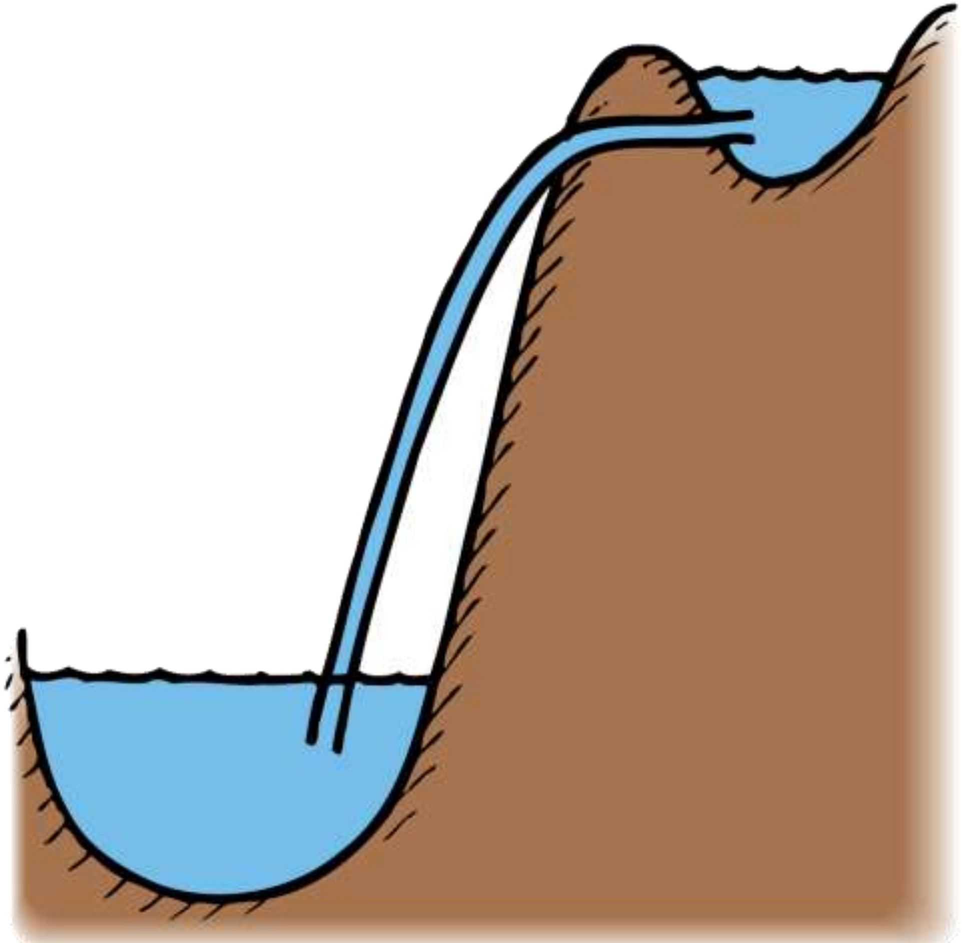
Heat will not necessarily flow from a substance with more total molecular kinetic energy to a substance with less.

- There is more total molecular kinetic energy in a large bowl of warm water than there is in a red-hot thumbtack.
- If the tack is immersed in the water, heat flows from the hot tack to the cooler water.
- Heat flows according to temperature differences—that is, average molecular kinetic energy differences.
- Heat never flows on its own from a cooler substance into a hotter substance.



21.2 Heat

Just as water will not flow uphill by itself, regardless of the relative amounts of water in the reservoirs, heat will not flow from a cooler substance into a hotter substance by itself.



21.2 Heat

CONCEPT CHECK

What causes heat to flow?

21.3 Thermal Equilibrium

When a thermometer is in contact with a substance, heat flows between them until they have the same temperature.

21.3 Thermal Equilibrium

After objects in thermal contact with each other reach the same temperature, we say the objects are in **thermal equilibrium.**

When objects are in thermal equilibrium, no heat flows between them.

21.3 Thermal Equilibrium

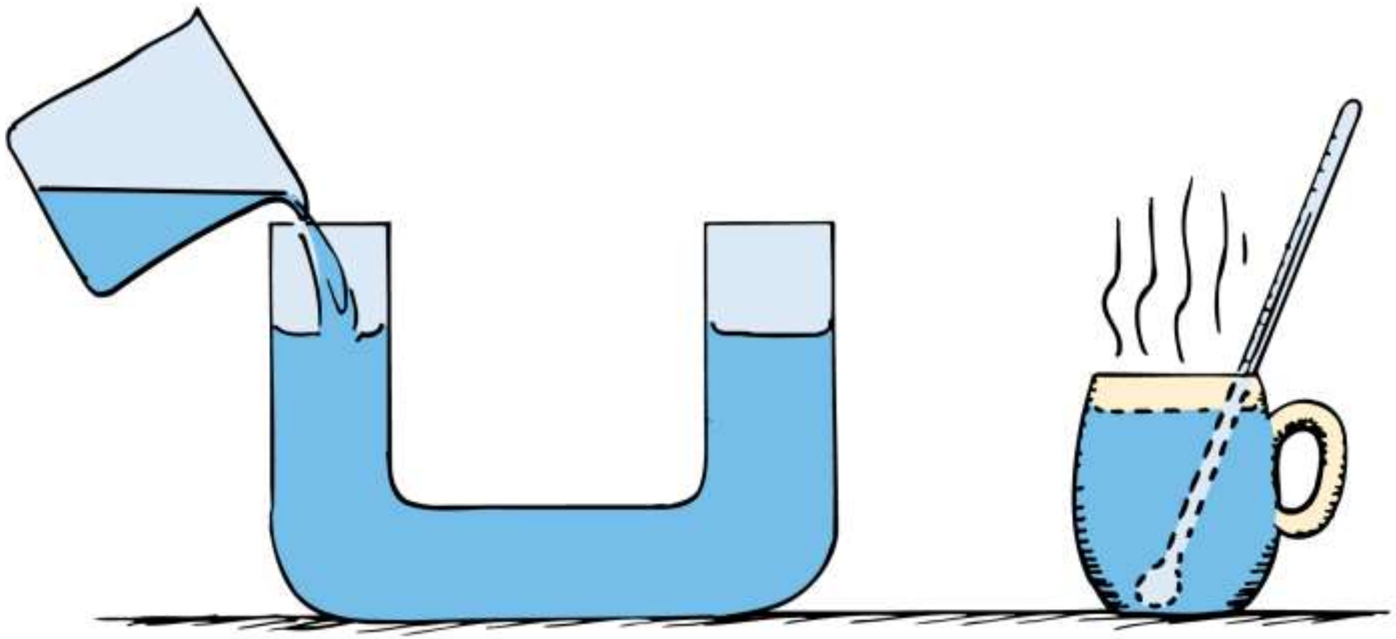
To read a thermometer we wait until it reaches thermal equilibrium with the substance being measured.

The temperature of the thermometer is also the temperature of the substance.

A thermometer should be small enough that it does not appreciably alter the temperature of the substance being measured.

21.3 Thermal Equilibrium

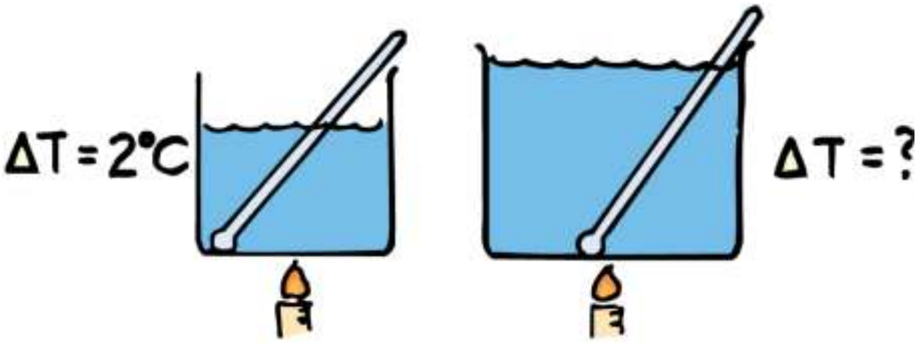
Water seeks a common level with pressures at equal elevations the same. The thermometer and its surroundings reach a common temperature with the average kinetic energy per particle the same.



21.3 Thermal Equilibrium

think!

Suppose you use a flame to add heat to 1 liter of water, and the water temperature rises by 2°C. If you add the same quantity of heat to 2 liters of water, by how much will its temperature rise?



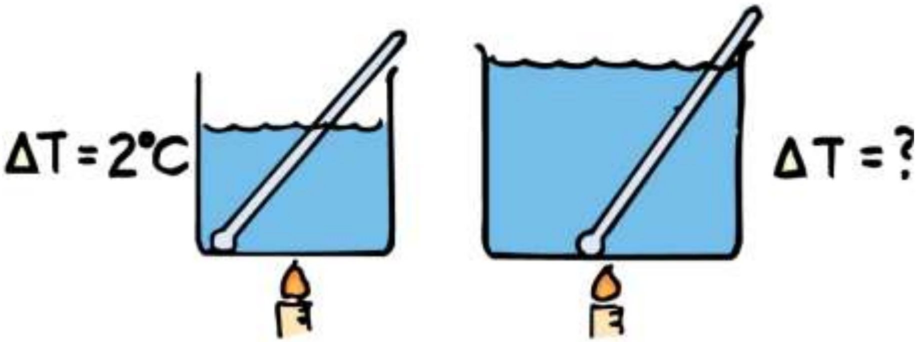
21.3 Thermal Equilibrium

think!

Suppose you use a flame to add heat to 1 liter of water, and the water temperature rises by 2°C. If you add the same quantity of heat to 2 liters of water, by how much will its temperature rise?

Answer:

Its temperature will rise by 1°C, because there are twice as many molecules in 2 liters of water and each molecule receives only half as much energy on average.



21.3 Thermal Equilibrium

CONCEPT CHECK

How does a thermometer measure temperature?

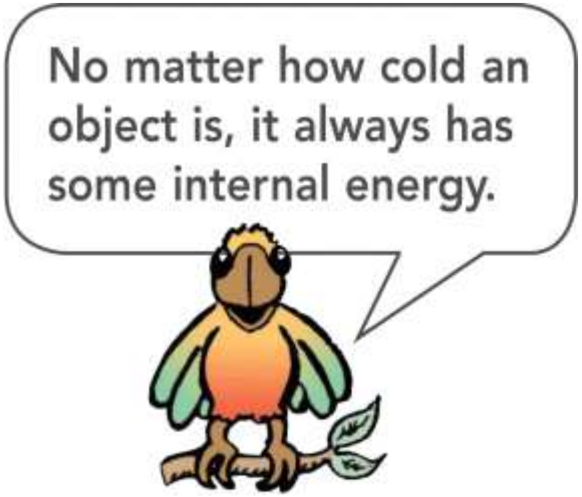
21.4 Internal Energy

When a substance takes in or gives off heat, its internal energy changes.

21.4 Internal Energy

In addition to the translational kinetic energy of jostling molecules in a substance, there is energy in other forms.

- There is rotational kinetic energy of molecules.
- There is kinetic energy due to internal movements of atoms within molecules.
- There is potential energy due to the forces between molecules.
- The total of all energies inside a substance is called **internal energy.** A substance contains internal energy, not heat.



21.4 Internal Energy

Absorbed heat may make the molecules of a substance jostle faster.

In some cases, as when ice is melting, a substance absorbs heat without an increase in temperature.

The substance then changes phase.

21.4 Internal Energy

CONCEPT CHECK

What happens to the internal energy of a substance that takes in or gives off heat?

21.5 Measurement of Heat

The amount of heat transferred can be determined by measuring the temperature change of a known mass of a substance that absorbs the heat.

21.5 Measurement of Heat

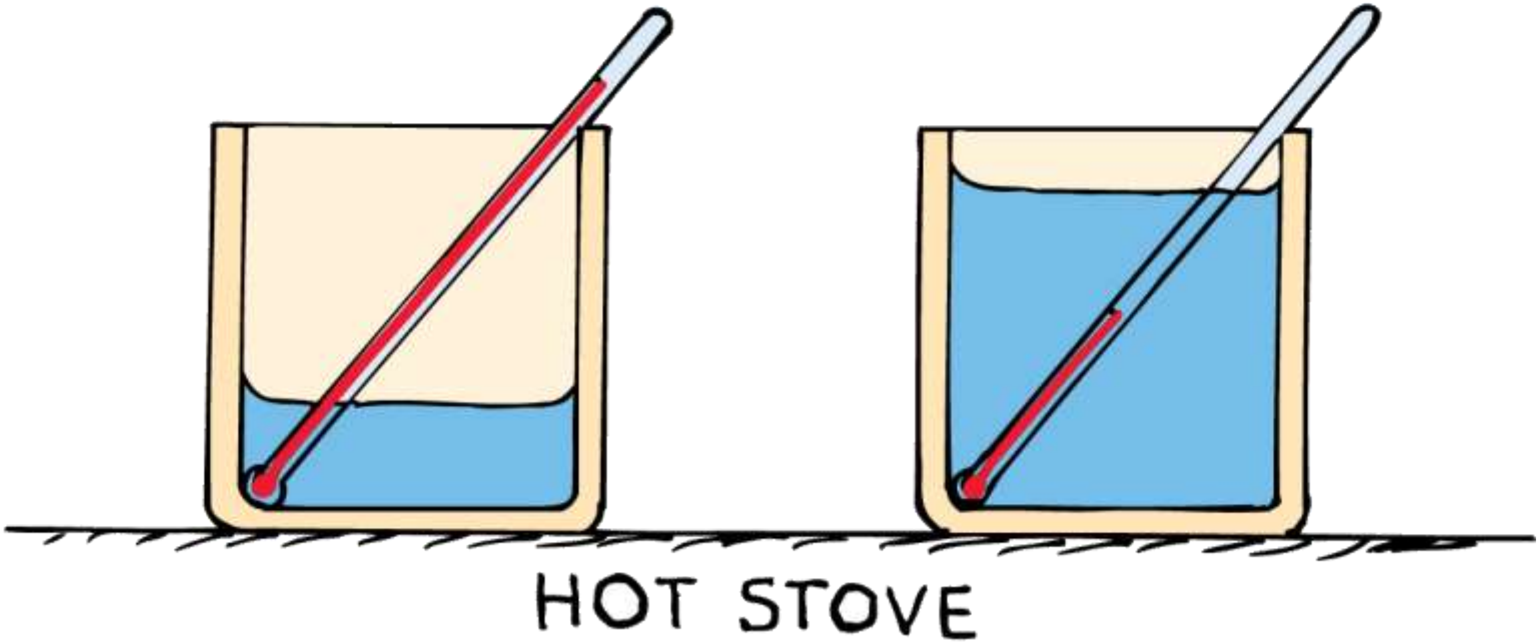
Heat is energy transferred from one substance to another by a temperature difference.

When a substance absorbs heat, the resulting temperature change depends on more than just the mass of the substance.

To quantify heat, we must specify the *mass* and *kind* of substance affected.

21.5 Measurement of Heat

Although the same quantity of heat is added to both containers, the temperature of the container with less water increases more.



21.5 Measurement of Heat

The unit of heat is defined as the heat necessary to produce a standard temperature change for a specified mass of material.

The most commonly used unit for heat is the *calorie.*

The **calorie** is defined as the amount of heat required to raise the temperature of 1 gram of water by 1°C.

21.5 Measurement of Heat

The **kilocalorie** is 1000 calories (the heat required to raise the temperature of 1 kilogram of water by 1°C).

The heat unit used in rating foods is actually a kilocalorie, although it’s often referred to as the calorie.

To distinguish it from the smaller calorie, the food unit is sometimes called a Calorie (written with a capital C).

21.5 Measurement of Heat

The calorie and the Calorie are units of energy.

In the International System of Units (SI), quantity of heat is measured in joules, the SI unit for all forms of energy.

One calorie equals 4.186 J.

21.5 Measurement of Heat

The energy value in food is determined by burning the food and measuring the energy that is released as heat.

Food and other fuels are rated by how much energy a certain mass of the fuel gives off as heat when burned.

21.5 Measurement of Heat

To the weight watcher, the peanut contains 10 Calories; to the physicist, it releases 10,000 calories (or 41,860 joules) of energy when burned or digested.

21.5 Measurement of Heat

think!

Which will raise the temperature more, adding 1 calorie or 4.186 joules?

21.5 Measurement of Heat

think!

Which will raise the temperature more, adding 1 calorie or 4.186 joules?

Answer:

Both are the same. This is like asking which is longer, a 1-mile-long track or a 1.6-kilometer-long track. They're the same quantity expressed in different units.

21.5 Measurement of Heat

CONCEPT CHECK

How can you determine the amount of heat transferred to a substance?

21.6 Specific Heat Capacity

The capacity of a substance to store heat depends on its chemical composition.

21.6 Specific Heat Capacity

Some foods remain hot much longer than others.

- Boiled onions, for example, are often too hot to eat while mashed potatoes may be just right.
- The filling of hot apple pie can burn your tongue while the crust will not when the pie has just been taken out of the oven.
- An aluminum foil covering can be peeled off with bare fingers right out of the oven, but be careful of the food beneath it.

21.6 Specific Heat Capacity

You can touch the aluminum pan of the frozen dinner soon after it has been taken from the hot oven, but you'll burn your fingers if you touch the food it contains.

21.6 Specific Heat Capacity

Different substances have different capacities for storing internal energy, or heat.

- A pot of water on a stove might require 15 minutes to be heated from room temperature to its boiling temperature.
- An equal mass of iron on the same flame would rise through the same temperature range in only about 2 minutes.
- For silver, the time would be less than a minute.

21.6 Specific Heat Capacity

A material requires a specific amount of heat to raise the temperature of a given mass a specified number of degrees.

The **specific heat capacity** of a material is the quantity of heat required to raise the temperature of 1 gram by 1 degree.

21.6 Specific Heat Capacity

Table 21.1 Specific Heat Capacities

Material	(J/g°C)	(cal/g°C)
Water	4.186	1.00
Aluminum	0.900	0.215
Clay	1.4	0.33
Copper	0.386	0.092
Lead	0.128	0.031
Olive Oil	1.97	0.471
Silver	0.23	0.056
Steel (iron)	0.448	0.107

21.6 Specific Heat Capacity

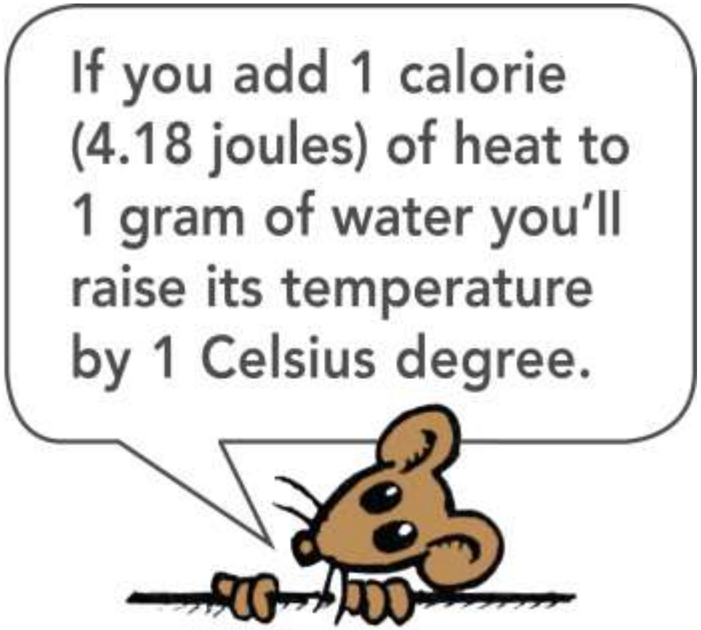
Recall that *inertia* is a term used in mechanics to signify the resistance of an object to change in its state of motion.

Specific heat capacity is like a thermal inertia since it signifies the resistance of a substance to change in its temperature.

21.6 Specific Heat Capacity

A gram of water requires 1 calorie of energy to raise the temperature 1°C.

It takes only about one eighth as much energy to raise the temperature of a gram of iron by the same amount.



21.6 Specific Heat Capacity

Absorbed energy can affect substances in different ways.

- Absorbed energy that increases the translational speed of molecules is responsible for increases in temperature.
- Temperature is a measure only of the kinetic energy of translational motion.
- Absorbed energy may also increase the rotation of molecules, increase the internal vibrations within molecules, or stretch intermolecular bonds and be stored as potential energy.

21.6 Specific Heat Capacity

Iron atoms in the iron lattice primarily shake back and forth, while water molecules soak up a lot of energy in rotations, internal vibrations, and bond stretching.

Water absorbs more heat per gram than iron for the same change in temperature.

Water has a higher specific heat capacity (sometimes simply called *specific heat*) than iron has.

21.6 Specific Heat Capacity

think!

Which has a higher specific heat capacity—water or sand? Explain.

21.6 Specific Heat Capacity

think!

Which has a higher specific heat capacity—water or sand? Explain.

Answer:

Water has a greater heat capacity than sand. Water is much slower to warm in the hot sun and slower to cool at night. Sand's low heat capacity, shown by how quickly it warms in the morning and how quickly it cools at night, affects local climates.

21.6 Specific Heat Capacity

CONCEPT CHECK

Why do different substances have different capacities to store heat?

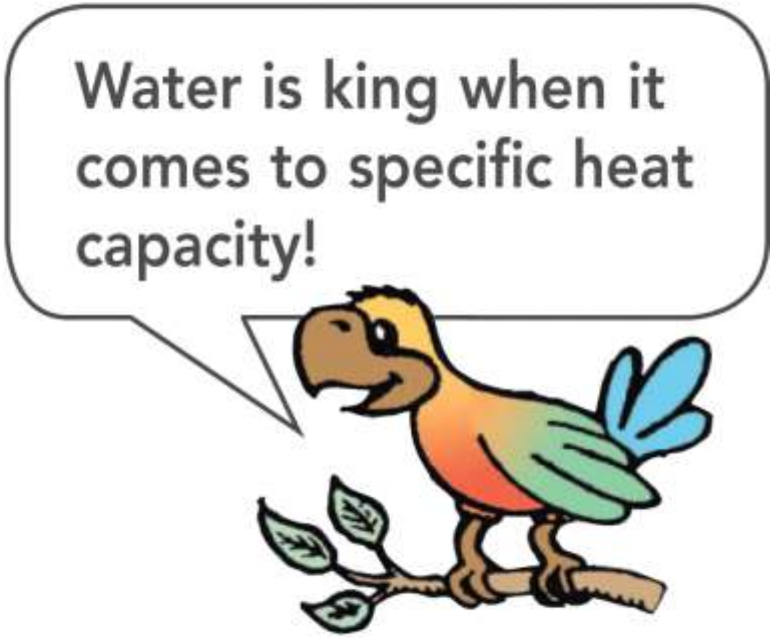
21.7 The High Specific Heat Capacity of Water

The property of water to resist changes in temperature improves the climate in many places.

21.7 The High Specific Heat Capacity of Water

Water has a much higher capacity for storing energy than most common materials.

A relatively small amount of water absorbs a great deal of heat for a correspondingly small temperature rise.



21.7 The High Specific Heat Capacity of Water

Because of this, water is a very useful cooling agent, and is used in cooling systems in automobiles and other engines.

For a liquid of lower specific heat capacity, temperature would rise higher for a comparable absorption of heat.

Water also takes longer to cool.

21.7 The High Specific Heat Capacity of Water

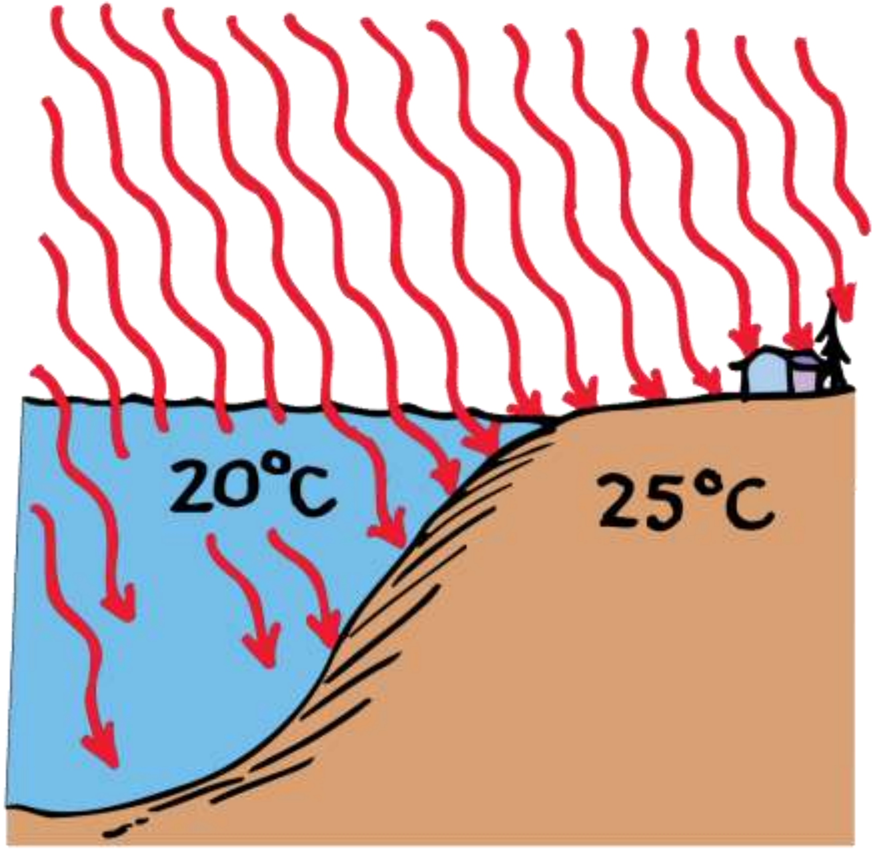
Water's capacity to store heat affects the global climate.

Water takes more energy to heat up than land does.

Europe and the west coast of the United States both benefit from this property of water.

21.7 The High Specific Heat Capacity of Water

Water has a high specific heat and is transparent, so it takes more energy to heat up than land does.



21.7 The High Specific Heat Capacity of Water

Climate of Europe

Look at a world globe and notice the high latitude of Europe.

Both Europe and Canada get about the same amount of the sun's energy per square kilometer.

21.7 The High Specific Heat Capacity of Water

The Atlantic current known as the Gulf Stream brings warm water northeast from the Caribbean.

It holds much of its internal energy long enough to reach the North Atlantic off the coast of Europe.

As it cools, the energy released is carried by the prevailing westerly winds over the European continent.

21.7 The High Specific Heat Capacity of Water

Climate of America

Climates differ on the east and west coasts of North America. The prevailing winds in the latitudes of North America are westerly.

On the west coast, air moves from the Pacific Ocean to the land.

- In winter, the water warms the air that moves over it and warms the western coastal regions of North America.
- In summer, the water cools the air and the western coastal regions are cooled.

21.7 The High Specific Heat Capacity of Water

On the east coast, air moves from the land to the Atlantic Ocean.

- Land, with a lower specific heat capacity, gets hot in summer but cools rapidly in winter.
- San Francisco is warmer in the winter and cooler in the summer than Washington, D.C., at about the same latitude.

The central interior of a large continent usually experiences extremes of temperature.

21.7 The High Specific Heat Capacity of Water

CONCEPT CHECK

What is the effect of water's high specific heat capacity on climate?

21.8 Thermal Expansion

Most forms of matter—solids, liquids, and gases—expand when they are heated and contract when they are cooled.

21.8 Thermal Expansion

When the temperature of a substance is increased, its molecules jiggle faster and normally tend to move farther apart.

This results in an *expansion* of the substance.

- Gases generally expand or contract much more than liquids.
- Liquids generally expand or contract more than solids.

21.8 Thermal Expansion

The extreme heat of a July day in Asbury Park, New Jersey, caused the buckling of these railroad tracks.

21.8 Thermal Expansion

Expansion Joints

If sidewalks and paving were laid down in one continuous piece, cracks would appear due to expansion and contraction.

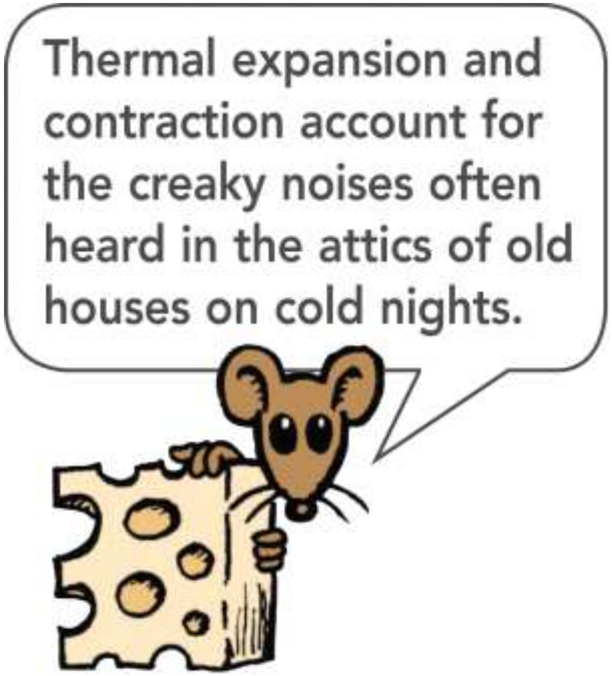
To prevent this, the surface is laid in small sections, separated by a small gap that is filled in with a substance such as tar.

On a hot summer day, expansion often squeezes this material out of the joints.

21.8 Thermal Expansion

Different materials expand at different rates.

- Dentists use material with the same expansion rate as teeth.
- Aluminum pistons of an automobile engine are smaller in diameter than the steel cylinders to allow for the much greater expansion rate of aluminum.
- Steel with the same expansion rate as concrete reinforces the concrete.
- Long steel bridges often have one end fixed while the other rests on rockers that allow for expansion.



21.8 Thermal Expansion

This gap is called an *expansion joint,* and it allows the bridge to expand and contract.

21.8 Thermal Expansion

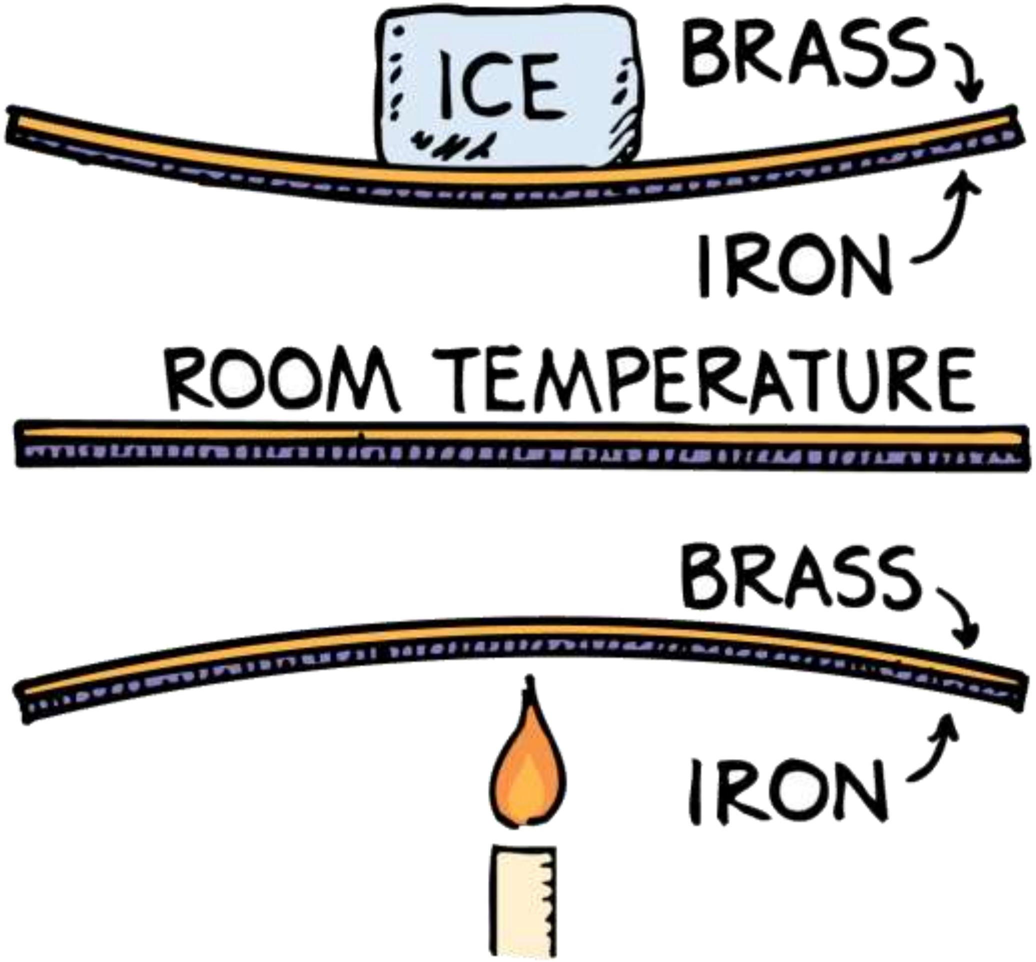
Bimetallic Strips

In a **bimetallic strip,** two strips of different metals are welded or riveted together.

- When the strip is heated, one side of the double strip becomes longer than the other, causing the strip to bend into a curve.
- When the strip is cooled, it bends in the opposite direction—the metal that expands the most also contracts the most.
- The movement of the strip can turn a pointer, regulate a valve, or operate a switch.

21.8 Thermal Expansion

In a bimetallic strip, brass expands (or contracts) more when heated (or cooled) than does iron, so the strip bends as shown.



21.8 Thermal Expansion

Thermostats

A **thermostat** is used to control temperature.

- As the temperature changes, the back-and-forth bending of the bimetallic coil opens and closes an electric circuit.
- When the room is too cold, the coil bends toward the brass side and closes an electric switch that turns on the heat.
- When the room is too warm, the coil bends toward the iron side and opens the switch and turns off the heating unit.

Bimetallic strips are used in refrigerators, oven thermometers, electric toasters, and other devices.

21.8 Thermal Expansion

When the bimetallic coil expands, the mercury rolls away from the electrical contacts, breaking the circuit. When the coil contracts, the mercury rolls against the contacts, completing the circuit.

21.8 Thermal Expansion

Glass

If one part of a piece of glass is heated or cooled more rapidly than adjacent parts, the expansion or contraction may break the glass.

This is especially true for thick glass.

Borosilicate glass expands very little with increasing temperature.

21.8 Thermal Expansion

think!

Why is it advisable to allow telephone lines to sag when stringing them between poles in summer?

21.8 Thermal Expansion

think!

Why is it advisable to allow telephone lines to sag when stringing them between poles in summer?

Answer:

Telephone lines are longer in summer, when they are warmer, and shorter in winter, when they are cooler. They therefore sag more on hot summer days than in winter. If the telephone lines are not strung with enough sag in summer, they might contract too much and snap during the winter.

21.8 Thermal Expansion

CONCEPT CHECK

How does matter change when heated or cooled?

21.9 Expansion of Water

At 0°C, ice is less dense than water, and so ice floats on water.

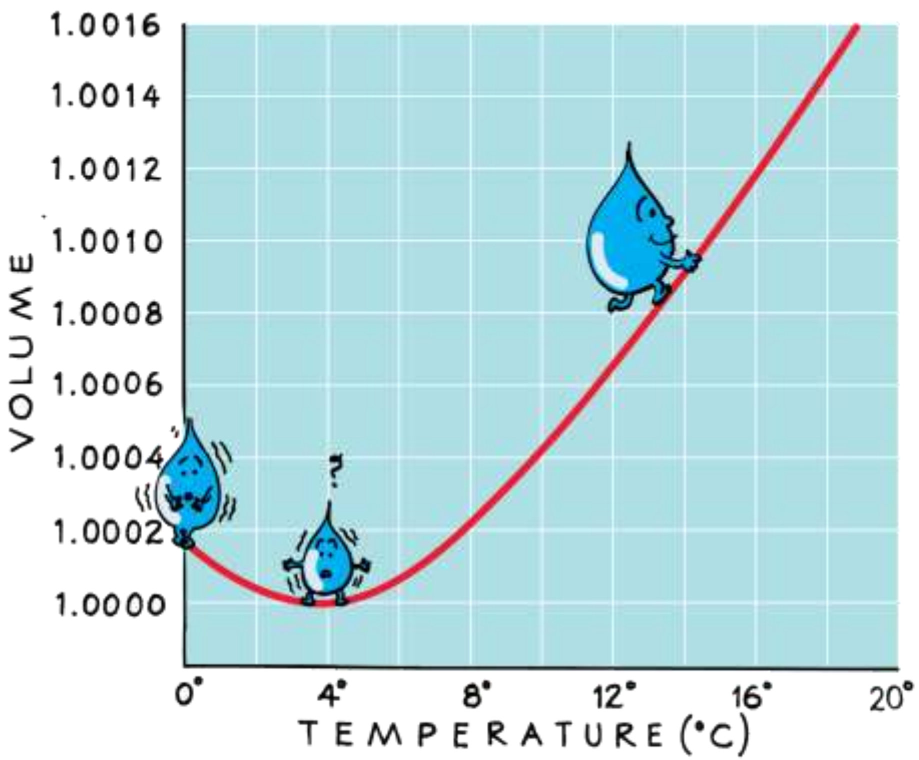
21.9 Expansion of Water

Almost all liquids will expand when they are heated. Ice-cold water, however, does just the opposite!

- Water at the temperature of melting ice—0°C (or 32°F)—*contracts* when the temperature is increased.
- As the water is heated and its temperature rises, it continues to contract until it reaches a temperature of 4°C.
- With further increase in temperature, the water then begins to *expand.*
- The expansion continues all the way to the boiling point.

21.9 Expansion of Water

The graph shows the change in volume of water with increasing temperature.



21.9 Expansion of Water

A given amount of water has its smallest volume—and thus its greatest density—at 4°C.

The same amount of water has its largest volume—and smallest density—in its solid form, ice. (The volume of ice at 0°C is not shown in the graph.)

After water has turned to ice, further cooling causes it to contract.

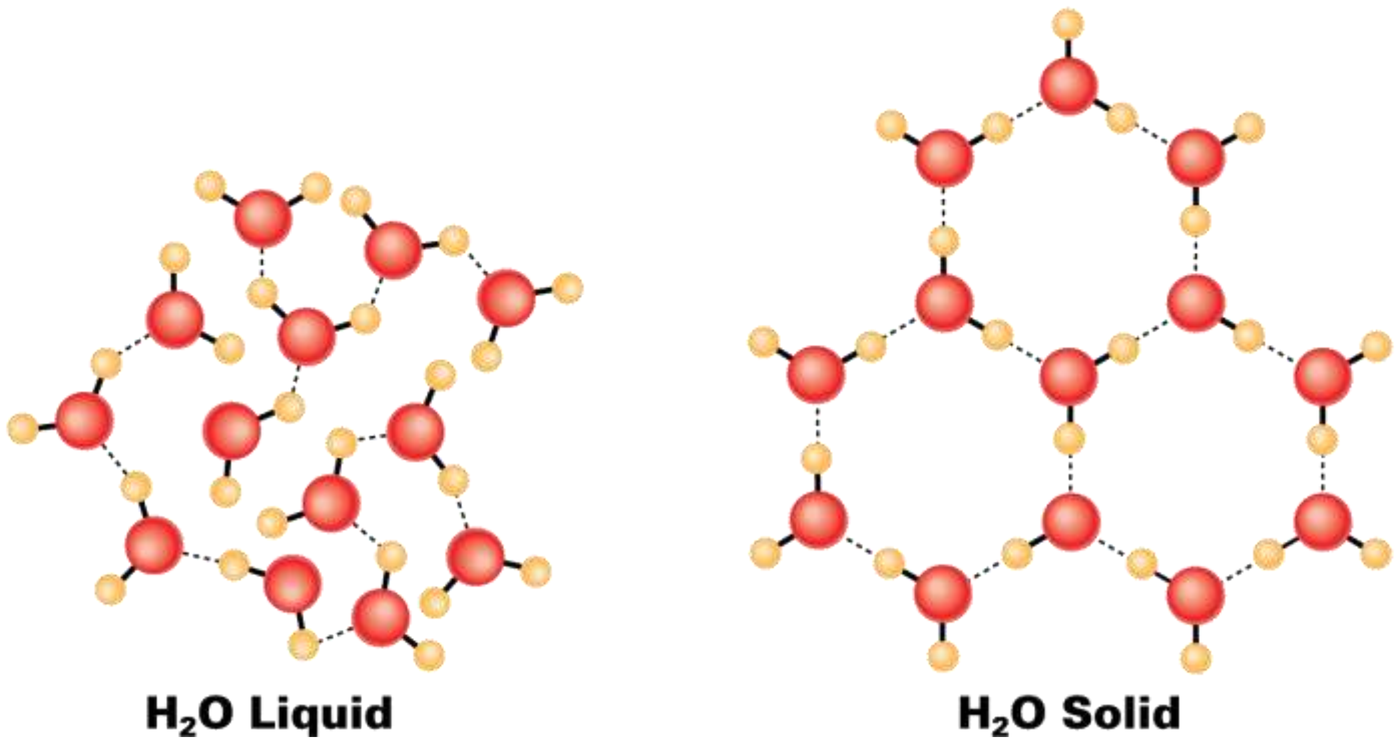
21.9 Expansion of Water

This behavior of water has to do with the crystal structure of ice.

- The crystals of most solids are structured so that the solid state occupies a smaller volume than the liquid state.
- Ice, however, has open-structured crystals due to the shape of the water molecules and the strength of the forces binding molecules together at certain angles.
- Water molecules in this open structure occupy a greater volume than they do in the liquid state.

21.9 Expansion of Water

Water molecules in their crystal form have an open-structured, six-sided arrangement. As a result, water expands upon freezing, and ice is less dense than water.



21.9 Expansion of Water

Melting Ice

When ice melts, some crystals remain in the ice-water mixture, making a microscopic slush that slightly “bloats” the water.

- Ice water is therefore less dense than slightly warmer water.
- With an increase in temperature, more of the remaining ice crystals collapse.
- The melting of these crystals further decreases the volume of the water.

21.9 Expansion of Water

The six-sided structure of a snowflake is a result of the six-sided ice crystals that make it up.

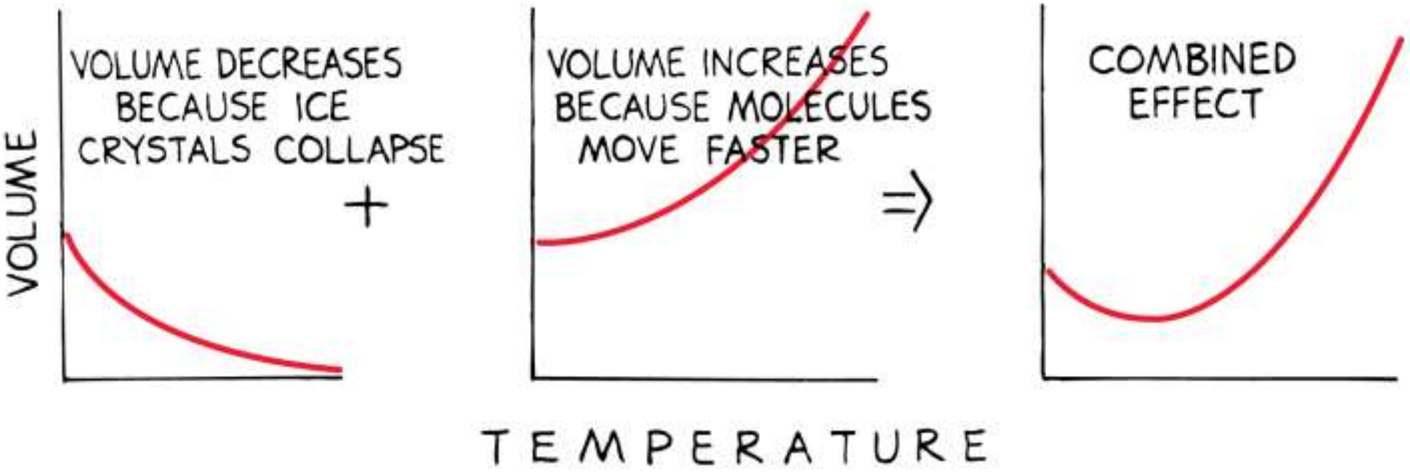
21.9 Expansion of Water

While crystals are collapsing as the temperature increases between 0°C and 10°C, increased molecular motion results in expansion.

Whether ice crystals are in the water or not, increased vibrational motion of the molecules increases the volume of the water.

21.9 Expansion of Water

The collapsing of ice crystals (left) plus increased molecular motion with increasing temperature (center) combine to make water most dense at 4°C (right).



21.9 Expansion of Water

This behavior of water is of great importance in nature.

Suppose that the greatest density of water were at its freezing point, as is true of most liquids.

- Then the coldest water would settle to the bottom, and ponds would freeze from the bottom up.
- Pond organisms would then be destroyed in winter months.

21.9 Expansion of Water

Fortunately, this does not happen.

- The densest water, which settles at the bottom of a pond, is 4 degrees above the freezing temperature.
- Water at the freezing point, 0°C, is less dense and floats.
- Ice forms at the surface while the pond remains liquid below the ice.

21.9 Expansion of Water

Freezing Water

Most of the cooling in a pond takes place at its surface, when the surface air is colder than the water.

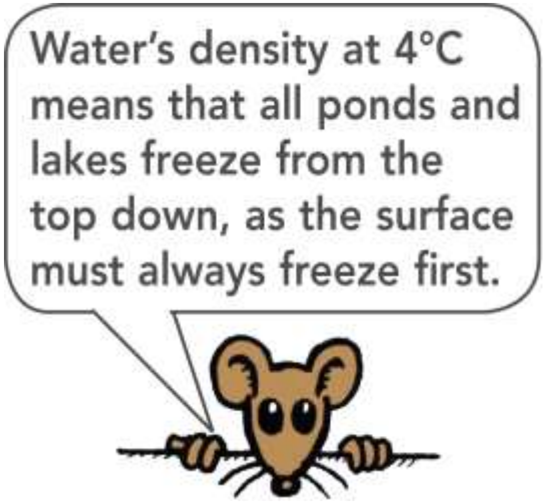
As the surface water is cooled, it becomes denser and sinks to the bottom.

Water will “float” at the surface for further cooling only if it is as dense as or less dense than the water below.

21.9 Expansion of Water

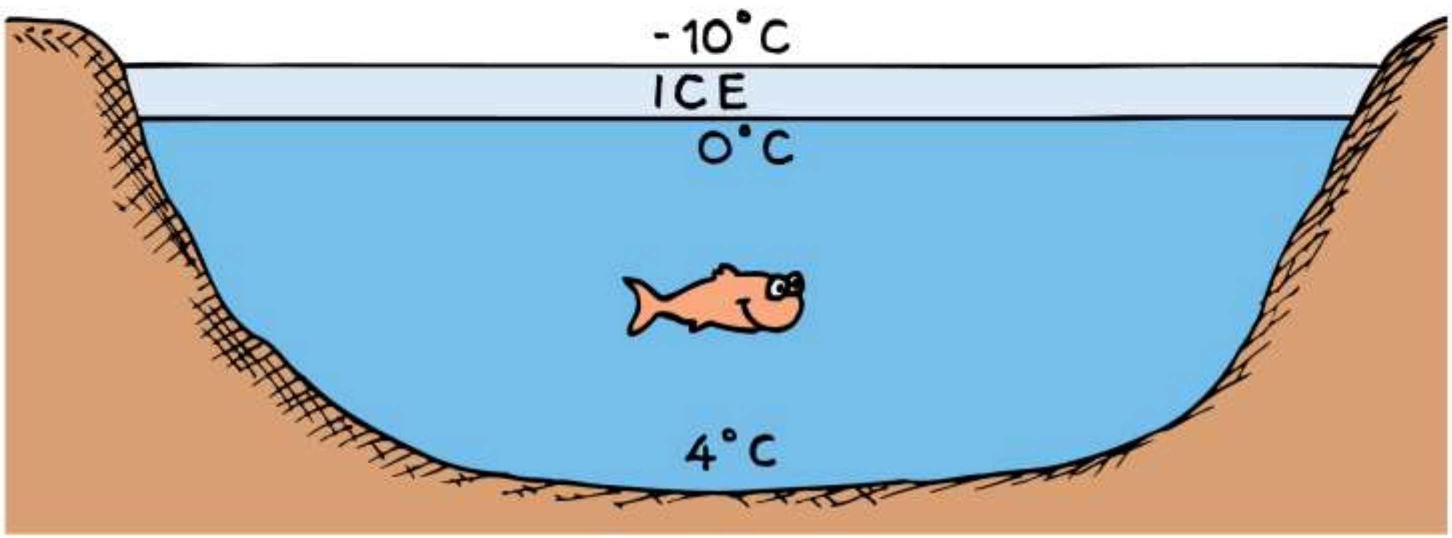
Consider a pond that is initially at, say, 10°C.

- It cannot be cooled to 0°C without first being cooled to 4°C.
- Water at 4°C cannot remain at the surface for further cooling unless all the water below has at least an equal density.
- If the water below the surface is any temperature other than 4°C, surface water at 4°C will be denser and sink.
- Ice cannot form until all the water in a pond is cooled to 4°C.



21.9 Expansion of Water

As water is cooled at the surface, it sinks until the entire lake is 4°C. Only then can the surface water cool to 0°C without sinking.



21.9 Expansion of Water

Thus, the water at the surface is first to freeze.

Continued cooling of the pond results in the freezing of the water next to the ice, so a pond freezes from the surface downward.

In a cold winter the ice will be thicker than in a milder winter.

21.9 Expansion of Water

Very deep bodies of water are not ice-covered even in the coldest of winters.

All the water in a lake must be cooled to 4°C before lower temperatures can be reached, and the winter is not long enough.

Because of water's high specific heat and poor ability to conduct heat, the bottom of deep lakes in cold regions is a constant 4°C.

21.9 Expansion of Water

CONCEPT CHECK

Why does ice float on water?

Assessment Questions

1. Temperature is generally proportional to a substance's
   a. thermal energy.
   b. vibrational kinetic energy.
   c. average translational kinetic energy.
   d. rotational kinetic energy.

Assessment Questions

1. Temperature is generally proportional to a substance's
   a. thermal energy.
   b. vibrational kinetic energy.
   c. average translational kinetic energy.
   d. rotational kinetic energy.

Answer: C

Assessment Questions

2. Heat is simply another word for
   a. temperature.
   b. thermal energy.
   c. thermal energy that flows from hot to cold.
   d. radiant energy.

Assessment Questions

2. Heat is simply another word for
   a. temperature.
   b. thermal energy.
   c. thermal energy that flows from hot to cold.
   d. radiant energy.

Answer: C

Assessment Questions

3. Which of these temperatures is likely when a container of water at 20°C is mixed with water at 28°C?

   a. 18°C

   b. 22°C

   c. 30°C

   d. 38°C

Assessment Questions

3. Which of these temperatures is likely when a container of water at 20°C is mixed with water at 28°C?

   a. 18°C

   b. 22°C

   c. 30°C

   d. 38°C

Answer: B

Assessment Questions

4. If you wanted to raise the internal energy of a bucket of 20°C water, you could
   a. place ice in the bucket.
   b. place it in a refrigerator.
   c. add 25°C water in the bucket.
   d. let the bucket stand at room temperature if the room is less than 20°C.

Assessment Questions

4. If you wanted to raise the internal energy of a bucket of 20°C water, you could
   a. place ice in the bucket.
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   c. add 25°C water in the bucket.
   d. let the bucket stand at room temperature if the room is less than 20°C.

Answer: C

Assessment Questions

5. The amount of heat transferred to a system can be measured in
   a. calories and grams.
   b. joules and calories.
   c. degrees Celsius and calories.
   d. kilograms and joules.

Assessment Questions

5. The amount of heat transferred to a system can be measured in
   a. calories and grams.
   b. joules and calories.
   c. degrees Celsius and calories.
   d. kilograms and joules.

Answer: B

Assessment Questions

6. Hot sand cools off faster at night than plants and vegetation. Then, the specific heat capacity of sand is
   a. less than that of plants.
   b. more than that of plants.
   c. likely the same as that of plants.
   d. not enough information to answer

Assessment Questions

6. Hot sand cools off faster at night than plants and vegetation. Then, the specific heat capacity of sand is
   a. less than that of plants.
   b. more than that of plants.
   c. likely the same as that of plants.
   d. not enough information to answer

Answer: A

Assessment Questions

7. To say that water has a high specific heat capacity is to say that water
   a. requires little energy in order to increase in temperature.
   b. gives off a lot of energy in cooling.
   c. absorbs little energy for a small increase in temperature.
   d. cools at a rapid rate.

Assessment Questions

7. To say that water has a high specific heat capacity is to say that water
   a. requires little energy in order to increase in temperature.
   b. gives off a lot of energy in cooling.
   c. absorbs little energy for a small increase in temperature.
   d. cools at a rapid rate.

Answer: B

Assessment Questions

8. When the temperature of a strip of iron is increased, the length of the strip
   a. increases.
   b. decreases.
   c. may increase or decrease.
   d. decreases in width as it gets longer.

Assessment Questions

8. When the temperature of a strip of iron is increased, the length of the strip
   a. increases.
   b. decreases.
   c. may increase or decrease.
   d. decreases in width as it gets longer.

Answer: A

Assessment Questions

9. Microscopic slush in water tends to make the water
   a. denser.
   b. less dense.
   c. slipperier.
   d. warmer.

Assessment Questions

9. Microscopic slush in water tends to make the water
   a. denser.
   b. less dense.
   c. slipperier.
   d. warmer.

Answer: B