LESSON CLUSTER 6
Heating and Cooling, Expansion and Contraction

Lesson 6.1: Another Way to Make Something Dissolve Faster

In the last lesson you learned one way to make things dissolve faster: you can stir the water. There is another way to make something dissolve faster, though. This way involves no stirring and no moving the cup. Do you know what it is? You can try this way in Activity 6.1.

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Do Activity 6.1 in your Activity Book

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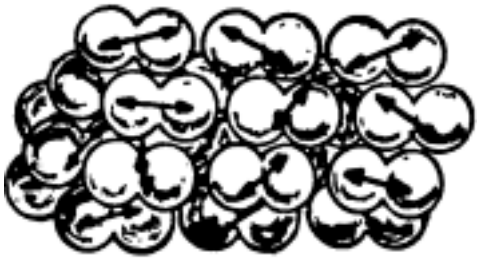
Did you know that when you say that something is “hot” or “cold,” you are actually saying something about the molecules of that substance? Words like “hot” and “cold” describe how fast or slow the molecules of a substance are moving. Hot substances have fast-moving molecules. Cold substances have slower-moving molecules.

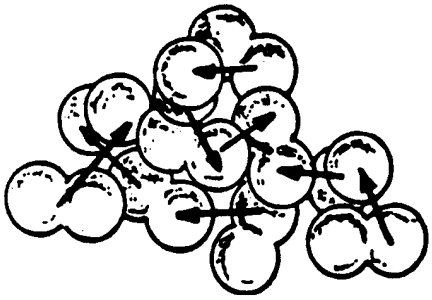
Heating any substance makes the molecules of that substance move raster. In hot solids, the molecules vibrate faster in their places. In hot liquids, the molecules move faster as they slide and bump past each other. In hot gases, the molecules move faster through space.

Cooling any substance makes the molecules of that substance move slower. In cold solids, the molecules vibrate more slowly in their places. In cold liquids, the molecules move more slowly as they slide and bump past each other. In cold gases, the molecules move more slowly through space. These differences between hot and cold substances are illustrated on the following page.



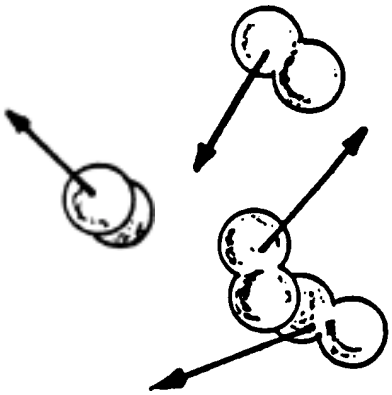
1. Cold solids: Molecules vibrate slowly in pla

2. Hot solids: Molecules vibrate quickly in place.

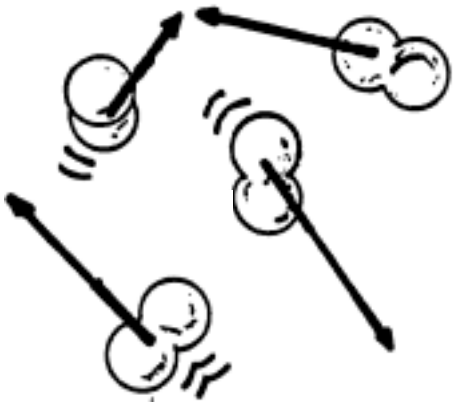


3. Cold liquids: Molecules slide and bump slowly past each other.

4. Hot liquids: Molecules move fast as they slide and bump past each other.



5. Cold gases: Molecules move slowly through space.



6. Hot gases: Molecules move fast through space.

Now let's try using these ideas to explain why the candy dissolved faster in hot water. We will talk about the cold water, then the hot water. We will answer

the question about substances and the question about molecules for each temperature of water.

In the cold water the candy (substance) dissolved slowly because the water molecules were moving slowly as they knocked off molecules from the pieces of candy.

In the hot water the candy dissolved faster because the water molecules were moving faster and hit the candy more often. That made them knock the molecules off the pieces of candy more quickly.

Did the explanation about hot water answer both the question about substances and the question about molecules? Find the parts of the explanation that answer each question.

When molecules are moving faster they make substances dissolve faster. Fast-moving molecules cause other effects, too. You will learn about one of those other effects in the next three lessons.

Lesson 6.2: Heating Solids

Heating a solid, such as a metal ball, makes the molecules vibrate faster. This fast vibration makes the ball feel hot when you touch it. The fast vibration of the molecules has another effect, too, one that is harder to see or feel. When the molecules vibrate faster they actually push each other a little farther apart.

So what happens when all the molecules of a solid push each other a little farther apart? The solid gets a little bigger, or expands. So heating solid objects makes the objects expand. This process is called thermal expansion ("thermal" means "with heat").

Let's try using these ideas to explain why a metal ball that barely fits through a ring won't go through the ring after it is heated. In this explanation we will talk about molecules first, then substances. As long as an explanation answers both questions, though, it is still a good explanation.

Heating the ball made the molecules of the metal vibrate faster, so they pushed each other farther apart. This made the metal ball expand (substance), so it would no longer fit through the ring.

Metal balls are not the only things that expand when heated. All solids expand when they are heated (unless heating causes some of the molecules to break up or makes the solid lose molecules). Concrete, rocks, metal objects, glass, and other solids all expand when they are heated. They all expand for the same reason, too. Their molecules move faster and push each other farther apart.

When solids cool, the molecules slow down. This allows the molecules to move closer together, so the solids contract. Solids expand when they are heated. They also contract when they are cooled; this process is called thermal contraction.

It is hard to see solids expand and contract because the molecules move only slightly farther apart or closer together. We have to measure the solids very carefully to tell that their size has changed.

Now try using what you know about thermal expansion and contraction to answer some questions about other situations where solids are heated or cooled.

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Do Question Set 6.2 in your Activity Book

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Lesson 6.3: The Thermometer

In the last two lessons you have learned that the molecules of all substances move faster when the substances are heated, and that solids expand when they are heated and contract when they are cooled. What about liquids? Do you think that they expand and contract the way solids do? Try Activity 6.3 and find out!

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Do Activity 6.3 in your Activity Book

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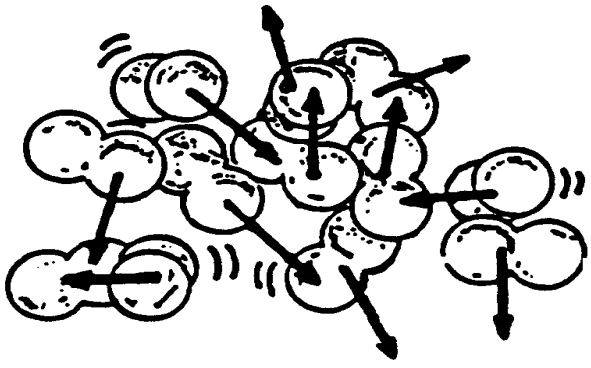
Could you explain why the column of the liquid in the thermometer rose and then fell? You know from Lesson 6.1 that the molecules of liquids move faster when the liquid is heated. That is one way that liquids and solids are alike.

Liquids and solids are also alike in another way. When the molecules move faster, they bump into each other harder and push each other farther apart. So just like solids, liquids expand when they are heated.

Liquids also contract when they are cooled. When the molecules of a liquid slow down, they move closer together. So liquids go through thermal expansion and thermal contraction just as solids do.



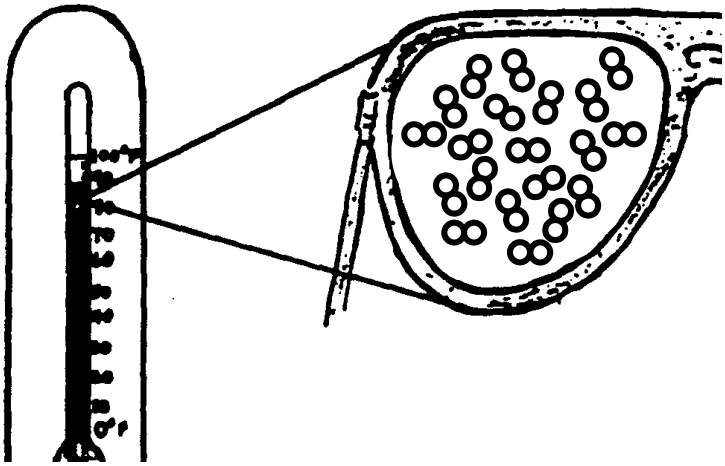
Heating makes the molecules of a liquid move faster and push each other farther apart

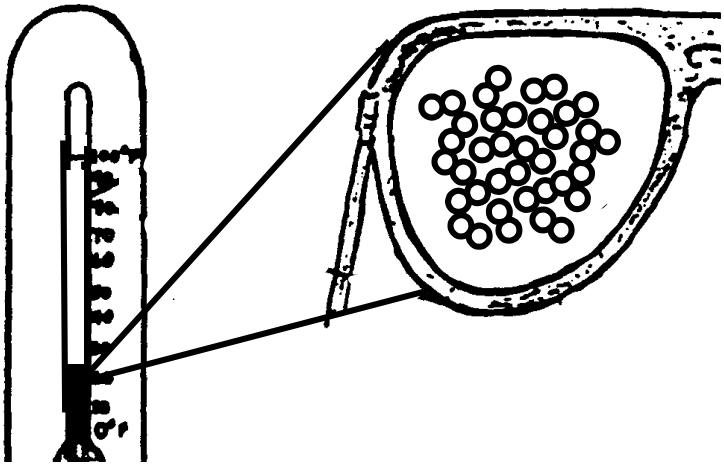
Cooling slows down the molecules of a liquid and they move closer together

Now we can explain how the thermometer works. Compare the explanations below to the ones you wrote in your Activity Book. Did you answer the questions about substances and the questions about molecules in the same way as the explanations below?

When you place the bulb of the thermometer in hot water, the molecules of the colored liquid move faster and push each other farther apart. This causes the colored liquid to get larger or expand. The colored liquid expands up through the thermometer tube which gives a higher temperature reading.

When you place the bulb of the thermometer in cold water, the molecules of the colored liquid move slower and come closer together. This causes the colored liquid to get smaller or contract. The contraction makes the column of colored liquid move down toward the bulb. This gives a lower temperature reading.



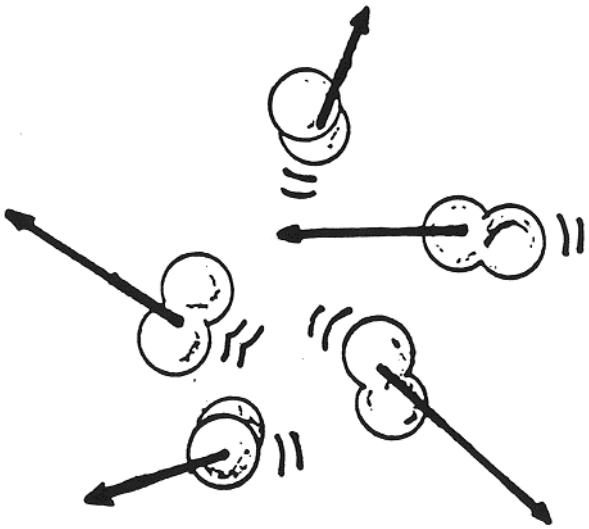


Lesson 6.4: Gases and the Dancing Dime

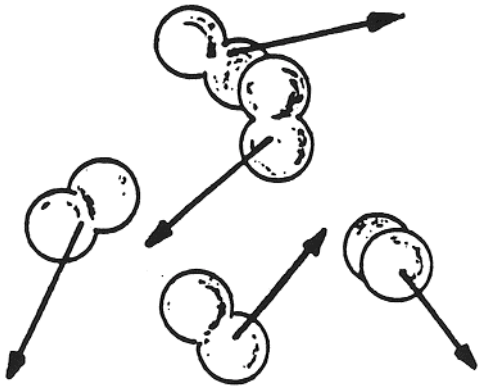
Solids expand when they are heated and contract when they are cooled. So do liquids. It probably won't surprise you that gases act the same way. Gases also expand when they are heated and contract when they are cooled.

The molecules of a hot gas move faster than the molecules of a cold gas, so they hit each other harder and bounce harder off the sides of a container. This makes the molecules move farther apart and push the sides of a container outward.

Cooling is just the opposite. The molecules slow down, so they don't hit each other or the walls of a container as hard, and they move closer together.



Hot gases have fast-moving molecules that bounce farther apart



Cold gases have slow-moving molecules that stay closer together

Do you remember when you studied expansion and compression of gases in Lesson Cluster 4? Now you know two ways of moving the molecules of a gas closer together or farther apart!

In Lesson Cluster 4 you moved the molecules of gases closer together by pushing them together with pressure from something like a syringe or a bicycle pump. Another way to move the molecules closer together is to cool off the gas. Then the molecules slow down and move closer together even without an extra "push."

In Lesson Cluster 4 you moved the molecules of gases farther apart by releasing pressure, like when you released the plunger of the syringe or let the air out of the bicycle tire. Another way to move the molecules farther apart is to heat the gas. Then the molecules move faster and push each other farther apart.

Let's try that other way of getting gases to expand. The dancing dime will help you see it happen!

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Do Activity 6.4 in your Activity Book

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This lesson cluster is almost over. You knew before this lesson cluster that all substances are made of tiny particles called molecules. You knew that molecules are always moving.

In this lesson cluster you learned another important idea. The temperature of a substance tells you something about how fast the molecules are moving. Heating a substance makes the molecules move faster. Cooling a substance makes molecules move slower.

The motion of the molecules explains why solids dissolve faster in hot water, as well as thermal expansion and contraction. In Lesson Cluster 7 you will use these ideas about molecular motion to explain melting and freezing.

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Do Review Question Set 6.4 Now

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