Name _____
Date _____
Block _____

LESSON CLUSTER 6: Expansion and Contraction

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. In fact, when we talk about a substance's **temperature**, we are actually describing the average kinetic energy (energy of motion) of the molecules in a substance.

Heating any substance makes the molecules of that substance move faster. 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 another handout.

You have already learned how hot and cold substances dissolve materials differently. Now, we'll look at other effects of heating and cooling.

Lesson 6.1: 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. Heating the ball made the molecules of the metal vibrate faster, so they pushed each other farther apart. This made the metal ball expand, 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.

Name _____
Date _____
Block _____

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

Question Set 6.1

1. Summarize the main points of this lesson by writing two sentences, one about heating solids, and one about cooling solids. Your sentences should mention both changes in substances and molecules.
    a. Heating solids:

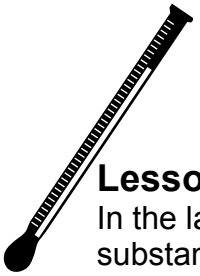
    b. Cooling solids:

2. Three of my friends were arguing about why heating the metal ball made it bigger. This is what they said:
    Barry: The ball gets bigger because the heat makes the metal molecules expand.
    Mary: The ball gets bigger because you are adding heat molecules to the ball.
    Terry: The metal molecules are still the same size but they move farther apart.
    a. Who was right?

    b. Why do you think so?

3. My friend taught me a way to open stuck jar lids. If you run hot water over the lid, it gets a little looser and sometimes you can open it. Explain why this works using what you know about the molecules in solids.

4. Most sidewalks have cracks filled with tar every few meters. These are called expansion joints. During the summer these cracks are very narrow. During the winter they are wider. Explain why this happens. (Hint: First explain what happens to the concrete slabs, then explain what happens to the size of the cracks.)



Name _____
Date _____
Block _____

Lesson 6.2: The Thermometer

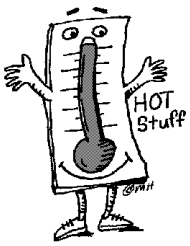
In the last lesson you learned that the molecules of all substances move faster when the substances are heated, and that solids expand when they are heated and contract when they are cooled. What about liquids? Do you think that they expand and contract the way solids do? Try Activity 6.2 and find out!

Activity 6.2

NOTE: DO NOT TOUCH THE BULB OF THE THERMOMETER DURING THIS ACTIVITY.

1. Look very carefully at the thermometer that your teacher gave you. The colored column looks thick when you look at it from the front, but that is because the glass magnifies it. Look at the thermometer from the side. Can you see how thin the column of colored liquid really is? Where is almost all of the colored liquid in the thermometer?

2. Read the temperature on the thermometer. Record it below.



3. Do you think the thermometer reading would change if you turned it in different directions? Find out! Without touching the bulb, try reading the thermometer when it's on its side and upside down. Does turning the thermometer around change the reading?

4. Now put the thermometer into warm water and watch what happens to the column of the colored liquid. Try explaining it below.
    a. What do you think happens to the molecules of the colored liquid when the water warms them up?

    b. How does that make the colored liquid move?

5. Try putting the bulb of the thermometer in cold water. What happens to the colored liquid?

*Adapted from **Matter and Molecules**: Institute for Research on Teaching, College of Education, Michigan State University*

Name _____
Date _____
Block _____

6. Explain what is happening to the molecules in the colored liquid when you put the thermometer in cold water. Look back at #4 as a model to help you.

7. My friend says that the liquid goes up when the bulb gets warmer because “heat rises.” This is not true. How could you use the thermometer to show your friend she is wrong?

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.

Now we can explain how the thermometer works. 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.

Name _____
Date _____
Block _____

Lesson 6.3: 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 also 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.

Do you remember when you studied expansion and compression of gases in Lesson Cluster 5? Now you know two ways of moving the molecules of a gas closer together or farther apart!

In Lesson Cluster 5 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 5 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!

Activity 6.3: The Dancing Dime

1. Your teacher will give you an empty soda bottle from the refrigerator. The bottle isn't really empty, though.
    a. What substance is inside it?

    b. Do you think that substance is hot or cold?

2. Wet the rim of the bottle and place a coin on it. Make sure that the space between the coin and the rim is wet enough to seal the opening so that nothing can get in or out. Wrap your hands around the bottle to warm it, but don't squeeze. What happened? Record your observations below.

3. Use what you know about substances and molecules to explain what happened.

Name _____
Date _____
Block _____

4. Instead of placing a coin on the rim of a cold soda bottle, my friend placed a balloon over the rim.
    a. What do you think will happen to the balloon as the bottle gets warm?

    b. Use what you know about molecules to explain what will happen to the balloon.

    c. My friend said that if you turn the soda bottle upside down, the balloon will get smaller. What do you think? Use what you know about molecules to explain your answer.

Cluster 6 Summary

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.

1. Try to summarize the main points of this lesson cluster by answering the two questions below. Talk about substances and molecules in each answer.
    a. What happens when substances are heated?

    b. What happens when substances are cooled?

2. Is it correct to say that heat makes the **molecules** of a substance expand? Why or why not?