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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.

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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.)

