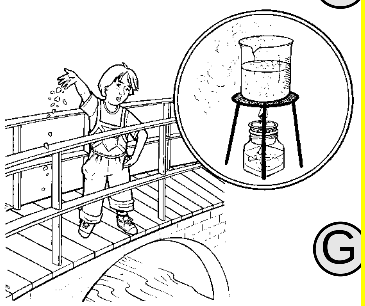
Category IV Physical Science Examples

Representing ideas effectively

Chemistry That Applies - Example 3
One representation that is used several times is likely to be confusing. To represent the loss of weight observed when water boils or when a chemical reaction produces a gaseous product, the text draws the analogy between these observations and the weight loss of a child who throws quarters or stones out of his pocket (pp. **23s**, **33s**, **40st**). This could be bewildering to students who think of the quarters as representing molecules because the quarters are not really a part of the person standing on the bridge. It would have been helpful to ask students to consider how the analogy is like and different from the real thing or how the analogy could be improved (e.g., by having the child spit off the bridge instead).

F



G

Here's how scientists would explain this. The last experiment—the one with boiling water—was different from the rest because as the water boiled, steam, which is a form of water, left the beaker. As the steam left the beaker, there was less water in the beaker, so it weighed less. It's like standing on a bridge, taking something heavy out of your pocket, and throwing it over the side. You now weigh less than before. As water boils, water molecules are going into the air, thus leaving fewer water molecules behind. Therefore it weighs less than it did before boiling.

THINK AND WRITE

Now try to answer the following questions in your journal:

1. What are all substances made up of? Use as much detail as you can.
2. What must happen to the substances involved in order for the weight of the materials to increase? to decrease?
3. Using this same sort of logic, how could you explain why a newly painted car would weigh more?
4. a. Did the steel wool change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.

   b. Did the water and ice cube change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.

   c. Did the sugar and water change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules.

   d. Did the boiling water change weight? Why or why not? Use molecules in your explanation. Then draw a picture that shows what is happening to the molecules in your experiment. Include bubbles in your picture and show what's in them.

F. Ask students what they know about steam. See if they know what is inside the bubbles. Many think that the bubbles contain air but they have no explanation for how the air got there. Some think there is nothing in the bubbles. Others simply have no idea of what is in them.

G. When the water heats up, bubbles form in the water. Each bubble contains some molecules of water. As the water gets hotter, the bubbles rise to the top, break and the water molecules fly off into the air.

1. All substances are made of molecules. Students have probably heard of molecules before so take a few minutes to see how their thinking about molecules relates to these substances. If students are not comfortable with the concept of molecules, take some time to discuss the concept. It is sufficient here if students understand that all substances are made up of particles and that these particles are called molecules. The concept of atoms and molecules are developed much more in Cluster 3 so there is no need to go into any detail here—especially, do NOT discuss atomic structure or formulas.

2. Some of the substance must be added to or taken away from the system—like throwing quarters out of your pocket or putting some quarters into your pocket.

3. The paint adds weight to the car.

4. a. No. The number of molecules stayed the same whether the steel wool was stretched or compacted. Nothing left the system when compacting the steel wool. Picture should depict molecules spread out and far apart, possibly lined up in strands. The compacted picture should show the molecules much closer together possibly still in strands. Be sure students show the same number of molecules for each in their pictures.

4. b. No. The number of molecules did not change as the ice melted and changed to water. They simply went into a new arrangement. The water and ice cube picture should show water molecules as random and disordered while the ice cube molecules are neat and orderly floating in the water. When melted, all the molecules should show the same randomness and disorder. Be sure that the number of molecules stays the same in the ice cube

THINK AND WRITE

1. a. Does the experiment support your prediction for the open system reaction?

   b. Does the experiment support your prediction for the closed system reaction?

2. a. Try to explain what happened to cause the weight change in the open system.

   b. Try to explain what happened which prevented a change in weight in the closed system.

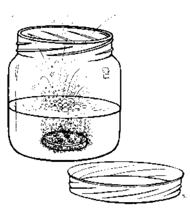
   c. Try to explain what happened when the bottle cap was opened.

3. What did you learn? Do gases have weight or not? What evidence do you have?

4. a. The reactants are ALL the substances you started with including any invisible gases, and the products are ALL the substance that were formed, including any invisible gases. Are they different in an open system than they are in a closed system?

   b. And now the big question, the one you've been trying to answer all along: How does the weight of the products compare to the weight of the reactants?

E Share your ideas with the class. Compare your thoughts with the thinking of the rest of the class.



Here's how scientists think about this reaction. When Alka-Seltzer reacted with water, it produced a gas which formed under the water. When trapped under water, the gas gets inside little, empty spaces or small pockets that we see as bubbles. The bubbles rise to the top of the water and break. The gas inside the bubbles flies off into the jar. If the jar does not have a cap on it (open system), then the gas leaves the jar and goes off into the air.

Would this result in a loss of weight? Is the reaction "throwing off" any quarters? You don't see anything leave the container, do you? But the evidence from your experiment is a weight loss. So something must be leaving, and whatever it is must have weight. It's the gas

1. a & b. Answers vary.

2. a. The cap was not on the bottle so the gases, which do have weight, escaped, and the system weighed less at the end than at the beginning.

   b. The cap was on the bottle so the gases, which do have weight, were trapped inside the bottle, and the system weighed the same at the end as it did at the beginning.

   c. When the cap was opened, the gases, which do have weight, escaped into the air, and the system weighed less than it did at the beginning.

3. Gases do have weight. The weight did not change when the gases were trapped inside the bottle, but when the gases were let out, the system got lighter.

4. a. No, since all substances are included whether they escaped or not, the reactants and the products always weigh the same.

   b. The weight of the products is equal to the weight of the reactants.

E. The class discussion should focus on the differences in weight when the gases are included and when they are not. Students should come to realize that often the products of a reaction are gases which are invisible. This leads many people to believe that matter is lost. The weight of the system after the reaction without the gases is actually less than the weight of the reactants, but the actual weight of the products is the same as the weight of the reactants.

5. Students should have no difficulty now predicting what should happen in the four reactions from the last lesson. In the first two, when bubbles formed and gases escaped, the weight of the system would be less because something (gas molecules) was let out of the system. But in the last two reactions, where you used a stopper or a balloon, the weight would be the same because now the gas molecules are trapped inside the system.

from the bubbles. They leave the container and take weight away with them. So gases must have weight!

Having trouble believing that gases have weight? So do lots of other people. Many people believe that nothing is inside bubbles, and that gases have no weight because they can't be seen or touched. They think that part of the substance just disappeared during the reaction.

Here's another way to think about this: Are the gases produced in this reaction matter or energy? If they are matter, then they are made of molecules. If they are composed of molecules, then they have weight. In fact, they are molecules of carbon dioxide gas. When gases leave a container, it is really molecules leaving the container, taking their weight away with them.

So what happened when the top was left on the bottles (closed system)? Could the gas inside the bubbles float off into the air? No. This time, the gases escaped from the bubbles and got into the air inside the bottle. But with the cap on the bottle, the gases could not get out of the bottle, so no weight left the container. Nothing could leave the closed system. The weight did not change. But when the cap was released (open system), the gases flew out into the air.

And what happened to the weight? It decreased because gases, which are matter and have weight, left the bottle. It's like throwing quarters out of your pocket.

Now go back to the four reactions you did in the previous lesson and review your predictions. Discuss each prediction and reason in your group. Remember that a correct prediction depends on whether you think any matter is leaving the container.

5. For each of the four reactions, use the new information you just learned to decide whether the weight would increase, decrease, or remain the same. Give a reason for your answer.

So where does all of this bring us now? These experiments all demonstrate one of the most fundamental laws of nature—the Law of the Conservation of Matter. It states that: Matter can neither be lost nor gained. It can only be changed from one form to another.

B. FOR GROUP DISCUSSION:

The steel wool reacted with something to gain weight and that something was probably oxygen from the air. The product weights more than the steel wool but it weighs the same as the steel wool and the oxygen together. It is like putting quarters into your pocket. Your new weight is the weight of you and the quarters together. In this case, the oxygen is comparable to the quarters. So the gases do not disappear—they change into a different substance which is no longer a gas. The product is black and powdery. It is iron oxide and is very similar to rust which is also iron oxide. Do not discuss formulas at this time.

1. The steel wool is very black. This looks different from normal rust.

2. The weight increased. This is surprising to most students, since they usually believe that things get lighter when they burn (e.g., wood ashes weigh less than the original wood).

3. Since its weight increased, something must have been added to it, like when you add stones to your pocket and your weight increases.

4. Either the "flame" or the gas from the Bunsen burner was involved in the reaction, or something from the air.

5. The best guess would be that oxygen from the air is used in this reaction. In fact, this is the case. Oxygen is "added" in some way to the steel wool, making it heavier. A complete explanation of this reaction is constructed in Lesson 3.

the steel wool about 10 to 15 cm from the ends of the meter stick. The steel wool should be suspended at least 8 to 10 inches below the meter stick. This will help prevent the stick from burning because of the heat from the Bunsen burner. Tape the hangers to the meter stick so they do not move during the experiment. Balance the set-up by moving the meter stick slightly to the left or right on the balance until all is level.

C. Make a prediction about how the weight might change if the steel wool is heated with a very hot Bunsen burner.

B

D. When all is balanced, heat the steel wool very intensely for five or six minutes with the Bunsen burner. Be sure to use the hottest part of the flame—the tip of the inner cone. When the steel wool begins to glow, remove the Bunsen burner. Observe what happens. Allow the product to cool and examine it. Has it changed?

THINK AND WRITE

1. Write a description of the product in your journal.
2. What happened to the weight after the steel wool was burned? Did this surprise you? Did you expect something else?

In your group, discuss the answers to the following questions. Be prepared to share your answers with the entire class.

3. Using the analogy of throwing stones out of your pocket to lose weight or picking up stones and adding them to your pocket to gain weight, write about whether the steel wool had something added to it or something taken away from it during the chemical reaction.
4. What, besides the steel wool, do you think might be involved in the reaction?
5. Remember, this reaction is similar to that of the rusting of steel wool. The same reactants are needed, and very similar products are formed. Can you now explain what happened with the steel wool rusting under the balloon?