

What is the Composition of Air?

Name: _____

Date: _____

Information: Elements and Mixtures

For thousands of years no one knew what air was made of. In the 1600's and 1700's more questions about air were being asked than ever. Was air an **element** OR could air be broken down into separate parts? Gold was considered an **element** because no one had ever broken down gold into separate, distinct parts. During the 1600's and 1700's water was believed to be an **element** and most people believed that air also was an **element**. Salt water was obviously not an element because it is made of two other separate substances—salt and water. Salt water was called a "**mixture**."

Critical Thinking Questions

1. Consider how the word "element" is used in the preceding paragraph. Do your best to define what is meant by "element."

Something that cannot be broken down into separate parts.

2. If you boil pure water for a long time, the pan will end up empty and dry because all of the water will boil away. If you boil salt water for a long time, there will remain a white crystalline powder in the bottom of the dry pan. Explain why the pan will NOT be empty like it was with the pure water.

Salt will be left behind in the pan.

3. As mentioned above, gold is an element and salt water is a mixture.

- a) Can you think of other things that are elements?

Anything on the periodic table

- b) Can you think of other things that are mixtures?

Pop, milk, sand, salad, etc.

4. Robert Boyle introduced the concept of searching for "elements," which he described as basic building blocks that were "perfectly unmingled." What do you think he meant by "perfectly unmingled?"

They were not mixed with anything. They were pure.

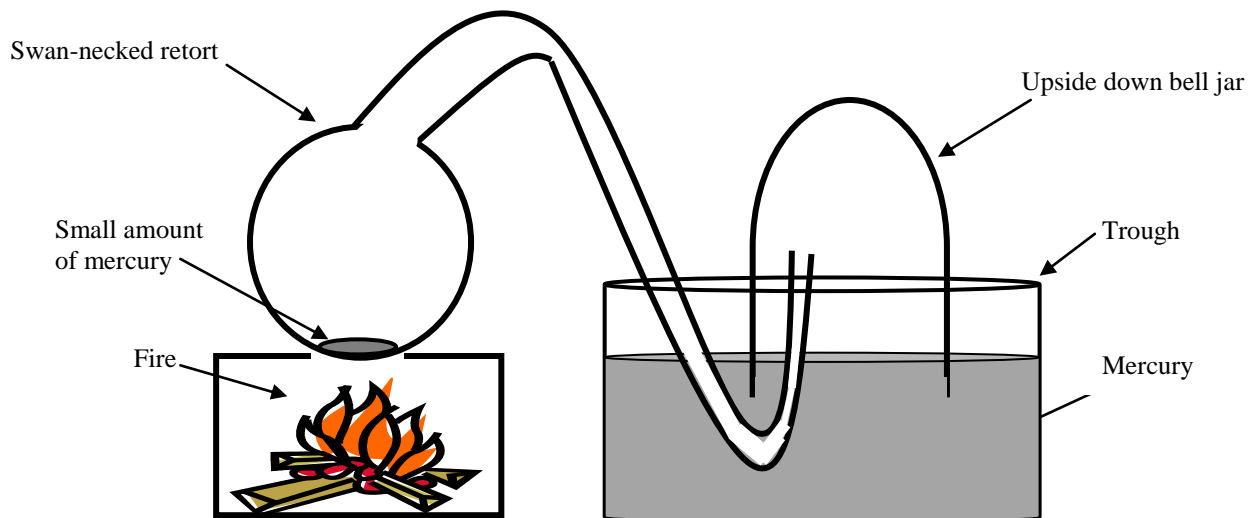
5. Sometimes it is nice to know what things are made of, isn't it? For example, if you tasted an unusually delicious cookie one of the first questions you might ask the baker is, "What's in this?" Why do you think that Boyle wanted to discover the "elements" that composed all things?

He wanted to have "building blocks" so that he could make new things.

Information: Lavoisier's Experiment

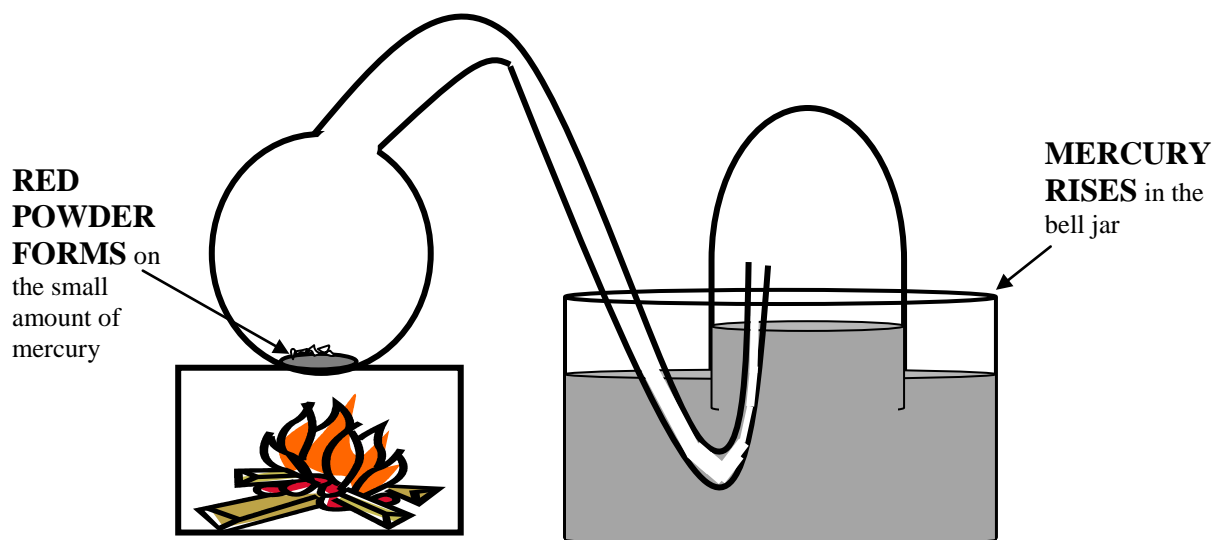
Approximately 100 years after Boyle, a French scientist by the name of Antoine Lavoisier (1743-1794) designed an ingenious experiment (See Figure 1) to attempt to discover if air was an element or if air was a mixture made of separate parts. Lavoisier used a coal oven to heat a small amount of mercury in a glass retort. The mouth of the retort was inserted in a glass bell-jar. Then the bell-jar was placed upside down in a trough filled with mercury.

Figure 1: Set-up of Lavoisier's Experiment



The total volume of the retort and the bell jar was 1000 mL. The heating was continued for several days. After the first few days of heating, Lavoisier observed a reddish powder on the surface of mercury in the retort. He also noticed that the mercury was rising up into the bell jar, as shown in the figure below:

Figure 2: Red powder forms on the mercury in the retort and mercury rises in the bell jar.



Critical Thinking Questions

6. Look at the set up in Figure 1. Was there any way that additional air could get into the glass retort or bell jar?

No, the mercury prevents additional air from entering the retort or the bell jar.

7. Mercury and air are in the retort and bell jar. Was Lavoisier primarily trying to learn about mercury or about the air?

He was trying to learn about the air primarily.

Information: Lavoisier's Data

After 12 days of heating the reddish powder appeared to have stopped forming and the level of mercury no longer rose in the bell jar. Lavoisier noticed that the rise in the level of mercury in the ball-jar was about 200 mL of mercury.

The air that was left in the bell jar and retort after heating was different than normal air. A candle would not burn in it. Also, a mouse would not be able to survive in the air either. Lavoisier named this type of air "azote," which means "without life" in Greek.

Lavoisier collected the reddish powder—which was only about 2 tablespoons—and heated it strongly in a different container. He obtained a shiny, metallic liquid metal (mercury) and a colorless, odorless gas. The volume of the gas was found to be 200 mL! When he lit a candle in this gas it burned much more brightly than it did when in normal air.

(Note: Joseph Priestly had previously burned the reddish powder and produced the colorless, odorless gas. Priestly also noted that a mouse could stay alive in a closed container of this gas five or six times as long as in normal air. Today, Priestly is given the credit for discovering this gas, but Lavoisier was the one who named it.)

Critical Thinking Questions

8. Lavoisier concluded from this experiment that the reddish powder was formed by a portion of the air combining with mercury. What experimental observations support this?

Mercury rose in the bell jar because some of the air that had been in the bell jar formed the red powder. Also, the remaining air was different in that it would not support a candle or a mouse. Part of the air had been turned into the red powder.

9. From this experiment it could be concluded that a solid takes up much less space than a gas. Prove this statement using observations from the experiment.

A small amount of red powder formed from apparently 20 mL of air.

10. The mercury rising into the bell jar was almost like someone was sucking the mercury into the jar as if the neck of the retort were a straw. Of course, no one was sucking the mercury into the bell jar. Why do you think the mercury was rising?

The mercury was taking the place of the air that formed the red powder.

11. Lavoisier said that his experiment proves that air is not an **element**. Do you agree with him? Why or why not?

I agree because a portion of the air was used up to form the red powder. Therefore air must be composed of at least two components.

12. Lavoisier said that the part of air necessary for breathing is the same part of the air necessary for burning. Do you agree? Site evidence from the experiment.

Yes. The remaining air after the red powder formed was unsuitable for burning a candle and also would not allow a mouse to breathe.

13. The component of air necessary for burning was called “oxygen” by Lavoisier. He claimed that air is made up of 20% oxygen. Use data from his experiment to show how Lavoisier calculated it. (By the way, “azote” was later renamed “nitrogen.”)

Out of the 1000 mL of air in the bell jar, 200 mL was combined with the mercury to form red powder, which equals 20% of the original air.