**The Conservation of Matter During Physical Changes and Chemical Reactions**

Matter makes up all visible objects in the universe, and it can be neither created nor destroyed.

*Citation: The National Geographic: Resource Library:* [*https://www.nationalgeographic.org/article/conservation-matter-during-physical-and-chemical-changes/12th-grade/*](https://www.nationalgeographic.org/article/conservation-matter-during-physical-and-chemical-changes/12th-grade/)

Matter makes up everything visible in the known universe, from porta-potties to supernovas. And because matter is never created or destroyed, it cycles through our world. Atoms that were in a dinosaur millions of years ago—and in a star billions of years before that—may be inside you today.

Matter is anything that has mass and takes up space. It includes molecules, atoms, fundamental particles, and any substance that these particles make up. Matter can change form through physical and chemical changes, but through any of these changes matter is conserved*.* The same amount of matter exists before and after the change—none is created or destroyed. This concept is called the Law of Conservation of Mass.

In a physical change, a substance’s physical properties may change, but its chemical makeup does not. Water, for example, is made up of two hydrogen atoms and one oxygen atom. Water is the only known substance on Earth that exists naturally in three states: solid, liquid, and gas. To change between these states, water must undergo physical changes. When water freezes, it becomes hard and less dense, but it is still chemically the same. There are the same number of water molecules present before and after the change, and water’s chemical properties remain constant.

To form water, however, hydrogen and oxygen atoms must undergo chemical changes. For a chemical reaction to occur, atoms must either break bonds and/or form bonds. The addition or subtraction of atomic bonds changes the chemical properties of the substances involved. Both hydrogen and oxygen are diatomic—they exist naturally as bonded pairs (H2 and O2, respectively). In the right conditions, and with enough energy, these diatomic bonds will break, and the atoms will join to form H2O (water). Chemists write out this chemical reaction as:

2H2 + O2 → 2H2O

This equation says that it takes two molecules of hydrogen and one molecule of oxygen to form two molecules of water. Notice that there are the same number of hydrogen atoms and oxygen atoms on either side of the equation. In chemical reactions, just as in physical changes, matter is conserved. The difference in this case is that the substances before and after the chemical reaction have different physical *and* chemical properties. Hydrogen and oxygen are gases at standard temperature and pressure, whereas water is a colorless, odorless liquid.

Ecosystems have many chemical reactions and physical changes happening all at once, and matter is conserved in each and every one—no exceptions. Consider a stream flowing through a canyon—how many chemical and physical changes are happening at any given moment?

First, let’s consider the water. For many canyon streams, the water comes from higher elevations and originates as snow. Of course, that’s not where the water *began*—it’s been cycled all over the world since Earth first had water. But in the context of the canyon stream, it began in the mountains as snow. The snow must undergo a *physical change*—melting—to join the stream. As the liquid water flows through the canyon, it may evaporate (another physical change) into water vapor. Water gives a very clear example of how matter cycles through our world, frequently changing form but never disappearing.

Next, consider the plants and algae living in and along the stream. In a process called photosynthesis, these organisms convert light energy from the sun into chemical energy stored in sugars. However, the light energy doesn’t produce the atoms that make up those sugars—that would break the Law of Conservation of Mass—it simply provides energy for a chemical reaction to occur. The atoms come from carbon dioxide in the air and water in the soil. Light energy allows these bonds to break and reform to produce sugar and oxygen, as shown in the chemical equation for photosynthesis:

6CO2 + 6H2O + light → C6H12O6 (sugar)+ 6O2

This equation says that six carbon dioxide molecules combine with six water molecules to form one sugar molecule and six molecules of oxygen. If you added up all the carbon, hydrogen, and oxygen atoms on either side of the equation, the sums would be equal; matter is conserved in this chemical change.

When animals in and around the stream eat these plants, their bodies use the stored chemical energy to power their cells and move around. They use the nutrients in their food to grow and repair their bodies—the atoms for new cells must come from somewhere. Any food that enters an animal’s body must either leave its body or become part of it; no atoms are destroyed or created.

Matter is also conserved during physical changes and chemical reactions in the rock cycle. As a stream carves deeper into a canyon, the rocks of the canyon floor don’t disappear. They are eroded by the stream and carried off in small bits called sediments. These sediments may settle at the bottom of a lake or pond at the end of the stream, building up in layers over time. The weight of each additional layer compacts the layers beneath it, eventually adding so much pressure that new sedimentary rock forms. This is a physical change for the rock, but with the right conditions the rock may chemically react too. In either case, the matter in the rock is conserved.

The bottom line is: Matter cycles through the universe in many different forms. In any physical change or chemical reaction, matter doesn’t appear or disappear. Atoms created in the stars (a very, very long time ago) make up every living and nonliving thing on Earth—even you. It’s impossible to know how far and through what forms your atoms traveled to make you. And it’s impossible to know where they will end up next.

This isn’t the whole story of matter, however, it’s the story of *visible* matter. Scientists have learned that about 25 percent of the universe’s mass consists of dark matter—matter that cannot be seen but can be detected through its gravitational effects. The exact nature of dark matter has yet to be determined. Another 70 percent of the universe is an even more mysterious component called dark energy, which acts counter to gravity. So “normal” matter makes up, at most, five percent of the universe.



Water can exist in three different physical states—as a gas, liquid, and a solid—under natural conditions on Earth. Regardless of its physical state, they all have the same chemical composition. Water is composed of two hydrogen atoms bonded to an oxygen atom.

NAME \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ GRADED: LAW OF THE CONSERVATION OF MATTER

 DUE: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Score: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

You should use this article, online research, or textbooks, as sources for answers to the following questions**.** Please be sure to answer each of the following questions. Please respond by typing your responses. Treat the questions as your lab report; write the question and then the answer. Cite your online sources and/or the texts you may use, by placing that citation after each answer. There is no need to cite this article, should you use it for reference.

1) Identify a difference between a physical change and a chemical reaction.

2) Identify a similarity between a physical change and a chemical reaction.

3) What must occur for something to be classified as a chemical reaction?

4) The article states: “*Atoms created in the stars (a very, very long time ago) make up every living and nonliving thing on*

 *Earth—even you.*”

 How does the article justify the above statement in terms of the Law of the Conservation of Matter?

5) Identify one big “take away” or one interesting thing you learned from the article, aside from the Law of the

 Conservation of Matter.